FEILDEN'S MAGAZINE.

34th Issue. MAY, 1902. Vol. 6. No. 5.

Industrial Aspects of the Housing Problem.

THERE is no more difficult and complicated question before the country just now than that which is called the Housing Question, and certainly none on which more confusion of thought prevails. But while the social, sanitarian, humanitarian, ethical and philanthropic aspects are widely—and more or less irrelevantly—discussed, the industrial aspects are, as a rule, almost invariably overlooked. And when they are not overlooked they are usually distorted and misunderstood. Yet it is in its industrial elements that one must really look for a solution of the problem that is just now perplexing all sorts and conditions of men. We are glad, therefore, to welcome in pamphlet form the paper which Mr. William L. Magden, M.I.E.E. recently read before the Society of Arts on "Industrial Redistribution,"— in which he finds (as do all who have got a right grip of the subject),—the crux of the over-crowding question. Mr. Magden regards the problem from the standpoint of a practical engineer, who has made a study of the economic conditions attaching to the distribution of our population.

The greatest mistake the housing reformers commit is in ignoring the dangers of making town life too cheap and comfortable for the poor. It is true that they are far from being agreed as to what and who "the poor" are, but their divergence of view does not mitigate the general error. All the schemes that have been proposed for the relief of congestion in London and other large towns must have the ultimate effect of increasing the congestion. Most of them will have the further effect of merely transporting the slums from the urban centres to the suburban districts. To provide cheap trains to deport the working-classes or labouring classes (as distinguished from the thriftless and shiftless, who will continue to loaf and grovel as long as the world lasts) from their places of employment to cheap dwellings in outlying areas, will be to increase the suburban as well as the central population. It will not check the growth of towns, which is the real cause of the evil with which men are now endeavouring to cope. Municipal authorities, with an eye to future assessments, may not desire to check the growth of urban population, but earnest social reformers do; and practical as well as theoretic economists are aware that a growth in urban population in excess of natural increase of births over deaths means the draining away of the rural population.

Now the draining away of the rural population from the land has two very serious consequences. It cripples and impoverishes our agricultural industry—still the greatest of our national industries—and it overcrowds the urban labour-markets. To the attractions of town life must be ascribed the emptying of the villages and the congestion of city slums. That being so, it will be a gigantic economic error to multiply the attractions of town life. To build houses in which the labourer or loafer may live in comfortable conditions,—palatial, perhaps, compared with what he has been accustomed to,—at considerably less than a true

economic rent: to provide steam or electric locomotion for him at the municipal expense, so that he can be moved from centre to suburb for an infinitesimal fraction of a penny per mile: is to invite the Hodges of England, the Sandies of Scotland and the Murphys of Ireland to leave their fields and fastnesses and come in denser streams than ever to towns already overcrowded with people and overburdened with traffic. And that is precisely the reverse of what is essential to a solution of the problem that underlies and surrounds the Housing question. In short, the Housing question cannot be settled, but will be aggravated, by the provision of cheap houses. It does not need either a mathematician, or a logician, or a physician, to demonstrate that you cannot cure congestion by intensifying the pressure at the centre. And one need not be an engineer to know that concentration of material where it is not wanted is waste of energy.

But concentration of people where they are not needed is something more than a waste of energy. It is an incubus on the cost of production. Where there is a great and growing population, the tendency of land, of rents, and therefore of living, is always upwards. Town labour is thus always dear labour, even when the town is overcrowded. Thousands of rural dreamers, longing after the flesh-pots of London, are kept back every year by the knowledge that they will have to pay there a very heavy price for the very small share of breathing space they can find. It is good that there is this deterrent, but, as we all know, it does not suffice. The stream rolls in from the country with ever-increasing strength. And it is the same with all the large towns.

Now the consequence of this is an enhancement of the cost of industrial production. All industries carried on in and near the neighbourhood of London and all big cities, have to pay big rents and big rates, and they also have to pay big wages because their employees have to pay big rents and big rates. That will not be cured by providing means for enabling the workers to live in the suburbs instead of near their work. Factory rents on urban lands will remain high, and wages for workers living on suburban lands will probably have to be higher to cover the cost of locomotion of themselves and families.

If, however, instead of taking the workers to the suburbs, we take the works to the country, the whole economic condition will be changed. In a sparsely populated rural district rents and rates are low, and therefore living is cheap. Workmen in small towns are better off with much lower wages than they require in London and the large cities.

It really seems absurd, when we think of it, how material is brought from all quarters to the most expensive centre that can be found, and there converted into commodities for distribution all over the country where everything is cheaper. Mr. Justice Grantham recently instanced the case of Doultons':—"They bring their clay from Dorsetshire and Cornwall, their coal from the Midlands and their salt from Cheshire to London: they use an enormous quantity of valuable and costly water, and having made their pipes and sanitary ware, they send them back to the source of origin of their component parts, as well as to all parts of the world."

The same kind of thing in other industries may be found at Glasgow, at Manchester, at Birmingham, at Leeds, &c., where industrial production is carried on under the worst possible economic conditions. And it is just where these bad economic conditions prevail, that overcrowding results and the Housing problem becomes acute.

What is meant by Industrial Redistribution is that factory work should be drawn away from the big towns and replanted in the small country towns or in vacant rural districts. We should aim at the multiplication of small industrial towns rather than at the building up of big commercial cities.

By the decentralisation of manufacturing industries many things will be gained. We

shall relieve, and in time permanently cure, the dangerous congestion of the large cities. We shall reduce the costs of industrial production. We shall improve the condition of the workers by giving them more space, better air and healthier surroundings. We shall improve the value of agricultural land, for every little town growing up round a factory will form a market for the farms surrounding it. And we shall improve the condition of the agricultural labourer by enabling him to earn better wages in a prospering industry while remaining within easy reach of the modest joys of small-town-dom. There are thousands of square miles up and down the country suitable for the formation of new industrial settlements. If the printing trade can migrate from overcrowded London to the villages, why not other trades?

Some political changes will be necessary. We shall have to get rid of the limited areas of local government that so hamper and reduce to burlesque the development of electrical engineering. As Mr. Magden pertinently remarks: "Now we have entered upon a new industrial era, it is a melancholy truth that not alone America and Germany, but even such countries as Italy and Switzerland, are showing us a lead. The daily papers and the man in the street thoughtlessly reproach the British electrical engineer, ignorant of the fact that there is a political as well as a technical side to the question of electrical progress; and that, however strenuously our engineers may persevere, they are helpless in face of the small tradesman who, as alderman or councillor, believes that the interests of his district would be imperilled by giving electrical enterprise fair play."

Well, Parliament must break down the barriers of ignorance and prejudice. For the redistribution of industries, in relief of the overcrowding of cities, we shall need the provision of cheap power for driving machinery, plenty of traffic facilities by means of light electric railways, the improvement of canals and waterways by the use of mechanical haulage, and so forth. Thus Industrial Redistribution will not only solve the Housing Problem but also provide a large field for electrical engineering.

Mr. Rhodes and British Progress.

We earnestly hope that everyone who has a desire to see maintained the supremacy of British trade in the world's markets will read the description in the April number of the *Review of Reviews* of the political policy and programme which Mr. Cecil Rhodes has left behind him as his Confession of Faith. Since the great man died, all the world has been talking of his will and the noble provision he has made therein for knitting together the colonies and the mother country, and for securing a good understanding between America, Germany and Great Britain, by the foundation of scholarships at Oxford University for the education of Colonials, Americans and Germans. This scheme, when published, gave the general public for the first time a conception of the great ideals which had occupied the mind of the founder of Rhodesia; and our knowledge of the man is further increased by the terms of his political programme. So far as it is purely "political" we are not concerned with it; but it is really an economic rather than a political document. His scheme was to create a "secret society," organised like that of the Jesuits, which should aim at making the world practically one large *British* market. "I believe that England, with fair play, should manufacture for the world." That was his faith; but he saw clearly the obstacles in the way of having his hopes realised. Seldom has the need for an awakening of the British people to a sense of their deficiencies been more forcibly put than it is by Mr. Rhodes.

"I have that inner conviction that if I can live I have thought out something worthy of being registered at the Patent Office; the fear is, shall I have the opportunity? And I believe with all the enthusiasm bred in the soul of an inventor it is not self-glorification I desire, but the wish to live to register my patent for the benefit of those who, I think, are the greatest people the world has ever seen, but whose fault is that they do not know their strength, their greatness, and their destiny, and who are wasting their time on their minor local matters, but being asleep do not know that through the invention of steam and electricity, and in view of their enormous increase, they must

now be trained to view the world as a whole, and not only consider the social questions of the British Isles.

"Even a Labouchere, who possesses no sentiment, should be taught that the labour of England is dependent on the outside world, and that, as far as I can see, the outside world, if he does not look out, will boycott the results of English labour."

In addition to these national deficiencies another obstacle presents itself in the foreign tariffs levied upon British goods. We dealt in our April issue with this question, and argued the necessity for protection of our industries against them. Mr. Rhodes in his usual forcible language points out the folly of our quiet submission to these attempts to kill our trade.

"Yet the fools do not see that if they do not look out they will have England shut out and isolated with ninety millions to feed and capable internally of supporting about six millions. If they had had statesmen they would at the present moment be commercially at war with the United States, and they would have boycotted the raw products of the United States until she came to her senses. And I say this because I am a Free Trader."

These are strong words, and they show that Mr. Rhodes was keenly alive to the dangers of the present unsatisfactory state of affairs. He was not, however, content merely with protesting; with his usual activity he desired to do something to obtain a remedy, and for this purpose he looked to the owners of capital for assistance. His "secret society" was to aim at drawing into its membership the wealth of the world, with which he might turn the tables on our rivals.

Whatever may be thought of the feasibility of his scheme, it cannot be doubted that the conception was a great one. There is nothing of self-seeking in it, and no desire for money for its own sake, but simply as a means to an end—the supremacy of the Trade of the British Empire. We cannot say that his dream is ever likely to be realised; but we earnestly hope that even if we pause in face of such a colossal scheme, we shall not allow the great issues which these expressions of Mr. Rhodes have raised, to be forgotten. We have always asserted our belief in the power of Britain to maintain her supremacy if she can only be roused to see how matters really stand, and to insist on facilities being provided for competition with her rivals on fair terms. Had Mr. Rhodes been spared, he might, with his great influence and enormous activity, have done much to bring about a better state of affairs, even had he failed to set his own scheme on foot; but the opportunity has not been given to him. In one matter his aid would have been especially useful. During the visit of Colonial Statesmen for the Coronation festivities a conference will be held for the exchange of views between them and the Colonial Secretary on the question of securing better trade regulations between the Colonies and Great Britain. Mr. Rhodes was almost the first to urge that the mother country was entitled, as a return for her development of the new countries, to have her produce admitted freely to Colonial markets, and in the early "nineties" he proposed to make it a condition in the Charter Constitution of his own new country that British goods should be protected for ever from protective and prohibitive duties being put upon them. The time is now ripe for such an arrangement with all the Colonies, and although he is no longer with us, others may be inspired by his words and example to carry on this work, and at the same time to rouse the people of this country to the knowledge that while "the labour question is an important matter, deeper than the labour question is the question of the market for the products of labour."

Canadian Minerals.

We fear that there is a tendency on the part of people in the Mother Country to overlook the importance of various developments in what are called Colonies, for want of a handier name. The recent report issued by the Statistical Department of the Dominion of Canada affords striking evidence as to the rapidly growing production of minerals in that country, where the yield of minerals was last year one-seventeenth that of the United States, the quantity equalling $12·6 per head of

the population, as compared with $14·3 per head in the United States. During the years 1891—1901, the increase per head has been practically double the increase shown in the latter country, and it is confidently anticipated that Canada will before long overtake the United States. Gold represents five-sevenths of the entire metallic production of the Dominion, the value for last year $27,908,000, while more than 136 million dollars worth has been produced since the commencement of this industry. The present output of copper in Canada is comparatively small, amounting to little more than three million dollars last year, but there are evidences that great developments are about to commence. Copper mining companies are already incorporated whose capital exceeds 140 million dollars, of which amount only a small proportion has yet been utilised, although nearly 50 of the companies are at work. We have recently made reference to the promising state of the Canadian iron and steel trades, from which great things may be expected in the immediate future. In non-metallic minerals satisfactory progress continues to be made. In 1890, the production of fuels in the United States and in Canada were represented by the proportion of 30 to 1, but in 1900 the figures were altered to 27 to 1 respectively, the increase in the former country during the period being 75·9 per cent., and in the latter 120·7 per cent. In structural materials, exclusive of iron and steel, the increase in Canada was 67 per cent, and in the United States only 19 per cent. All these statistics are well worthy of note.

A French View of the American Workman.

We have lately had a good many opinions from British visitors to the United States, and it is interesting to read the impressions made upon a French observer of industrial conditions in that country. We are told that the secret of the American workman's triumph rests in his strenuousness, his power of initiative, his independence, and his power of production. He believes in the machine, and is content with the doctrine that nothing should be done by hand that can be performed by machinery. In the well-appointed American factory, automatic machines are numerous, and men are few. Those who are employed have to work hard, talking during business hours is discouraged, the weak go to the wall, and the strong are well paid. Consequently, while paying high wages, the American manufacturer can afford to undersell his foreign rivals. As to the conditions of work, what appears most striking to the French student is the admirable discipline maintained. Quarrels and bad language are punishable by dismissal, smoking is generally forbidden, defective goods are charged to the workmen responsible, and cleanliness is enforced. In many works baths and toilet rooms are provided for the hands, and sometimes each man has a locker in which his outdoor clothes may be kept. Social conditions were also found to be superior to those prevailing in the old world. In many cases the workman keeps a horse and trap, he finds relaxation in travel, in social meetings and in religious work. His wife has an ample housekeeping allowance, she has time for reading, and is not infrequently a student of music, drawing, and foreign languages. Briefly stated, these are the points most noticeable to the observer to whom we refer. If we add that temperance is a characteristic of the American workman, the picture is complete. Of course there are Trades Unions, but such bodies in America do not try to destroy the happy state of prosperity in which the working classes live. If any organisation of the kind were foolish enough to try, the attempt would be vain, for the American citizen is not to be led by the nose after the manner of his British compeer.

Indian Railways.

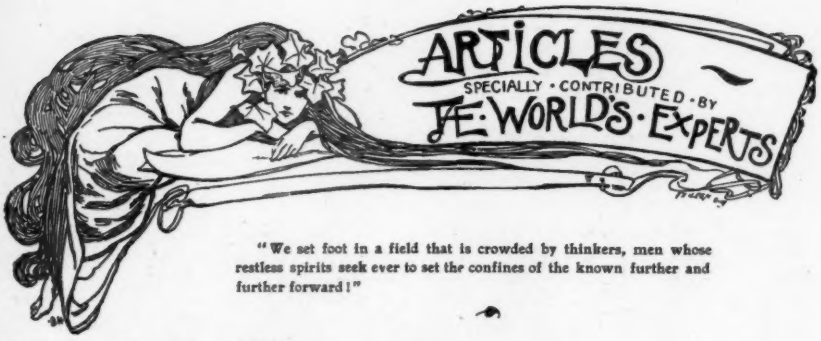
OUR readers will remember that a Committee was appointed last year by Lord Curzon, to consider the improvement of conditions prevailing on railways in the Indian Empire. We understand that this Committee has already made some recommendations, largely based on suggestions from the Government Director of State Railway Construction, but from the information at present available, we do not gather that any radical improvements are to be made. The standardisation of locomotives, rolling stock, and of engineer's stores used for repairs, is of extreme importance, but it is difficult to settle any permanent and satisfactory standards until the antiquated and unmeaning restrictions that throttle railway development have been replaced by modern and common-sense regulations.

Unhappily, the new proposals of the Indian Committee appear to be entirely inadequate so far as these standards are concerned, for the Government Consulting Engineers present at the conference vetoed the opinion that the existing regulations should be materially relaxed. It is true that a maximum axle weight of 18 tons for locomotives will in future be allowed, but only on first-class lines and under severe restrictions, one of which is that the new maximum will only be permitted on rails weighing 90 lbs. per yard. Even the cautious practice of railway engineers in Great Britain has for many years admitted axle weights from 19 to 20 tons, while American practice allows from 22 to 23 tons, in each case on rails of much lighter construction than those now demanded by the proposals of the Indian Committee.

In England, where steel is cheap as compared with timber and labour, and where ceaseless traffic adds to the difficulty and expense of repairs, a good deal may be said in favour of heavy rails, but even on many of our main lines 90-lb. rails are unknown. In the United States much lower standards of weight prevail, and it is quite exceptional for rails to be used weighing more than 75 lbs per yard. In fact, if sufficient sleepers are employed, 60-lb. rails fulfil all the ordinary requirements of American traffic. Yet the Indian Government will still insist upon 90-lb. rails, just as if the lines were to be laid in London or in Lancashire.

Apart from the points mentioned above, it should be remembered that although the chief Indian railways have the advantage of a gauge 9½ ins. wider than our own, locomotives have not hitherto been allowed, and under the new proposals will not be allowed, even of the inadequate proportions hitherto generally used in this country. British locomotive superintendents are now coming to the conclusion that the economical haulage of merchandise is impossible without larger engines and more capacious wagons. Many of them have recently visited the United States for the purpose of learning what is being done there, and on more than one railway it is believed we shall shortly find goods trucks of quite sensible proportions. There is no evidence of any such reform in India, where, in spite of the broader gauge, goods wagons are not allowed to carry so much as 90 per cent. of the weight per foot length carried in the narrow trucks used in our own country.

On the question of standardisation some progress has been made, for it was agreed that 17 standard types of locomotives should be adopted for the three gauges prevailing in India; but some of the designs are so much alike that the number of types suggested might be considerably reduced. The decision that the British builders should be invited to prepare designs for standard engines is satisfactory so far as it goes; but as the designs in question are to be submitted to the London consulting engineers for their opinions, it may be feared that the conditions of manufacture will not be materially improved. The conference thought it no part of their business to sit in judgment on the proceedings of eminent firms of engineers. This timidity can scarcely be regarded as a hopeful sign, but as the whole question is of supreme importance to the Home engineering industries, we trust that those who have already taken it up will persist in their efforts to bring about the necessary reforms.



"We set foot in a field that is crowded by thinkers, men whose restless spirits seek ever to set the confines of the known further and further forward!"

Silver-lead Mining at Broken Hill, N.S.W.

By H. F. BULMAN, A.M.Inst.C.E., F.G.S.

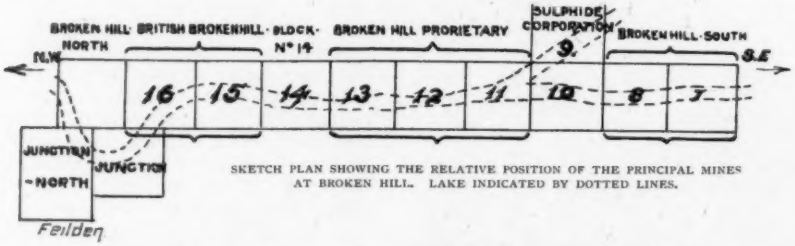
THE mineral wealth of Australia is attested by the fact that she possesses not only the greatest gold mine in the world in Mount Morgan, but also the most prolific silver-lead mine in Broken Hill Proprietary.

With its sister companies working the same lode side by side, this great mine is producing wealth to the amount of about five millions sterling yearly. The accompanying sketch plan shows the relative positions of the various companies now at work on the Broken Hill lode. The parent Company, the Broken Hill Proprietary, originally acquired and still holds a lease of the seven 40-acre blocks numbered 10 to 16 inclusive. It leases them from the Government of New South Wales at a small rental per acre, no tonnage rent being paid. It now works three blocks—11, 12, 13—itself, and it has sublet the other four to subsidiary companies; Block 15 and 16 to the British Broken Hill Proprietary Co.; Block 14 to Block 14 Co.; and Block 10 to Block 10 Co. Next to the parent Company, the Sulphide Corporation, Limited, are at present the largest producers. A few years ago they bought the Central Mine—as it is known at Broken Hill—with the view of getting the sulphide ores from the lower levels, and treating them by improved methods for the extraction of their valuable contents.

SITUATION.

Broken Hill is situated close to the western boundary line of New South Wales, some 900 miles from Sydney. It is reached best from Adelaide by rail, a journey which occupies about 15 hours. Apart from its mineral wealth, the district has no attractions. It is a region of drought and dust storms, an arid, sun-scorched, waterless plain, sparsely covered with poor scrub. From the plain rose to a height

of about 200 feet for a mile or two (before it was removed by mining) the rugged outcrop of the vast subterranean treasure store. The exploitation of this source of wealth has given birth to a substantial town with a prosperous population, numbering about 27,000, almost all of whom are dependent on the mines. The names of the streets, *e.g.* Argent, Wolfram, Kaolin, Oxide, Chloride Streets, harmonise with the main industry of the place. It is quite up-to-date, possessing a public park, comfortable hotels, a club, hospitals, and several churches and chapels. The writer happened to be there on the occasion of the annual Hospital Sunday, when a monster procession of Oddfellows and Druids and St. John's Ambulance men and trade unionists and cyclists paraded through the main streets to the strains of bands of music, and a sum of £132 was collected for the hospitals.



SKETCH PLAN SHOWING THE RELATIVE POSITION OF THE PRINCIPAL MINES AT BROKEN HILL. LAKE INDICATED BY DOTTED LINES.

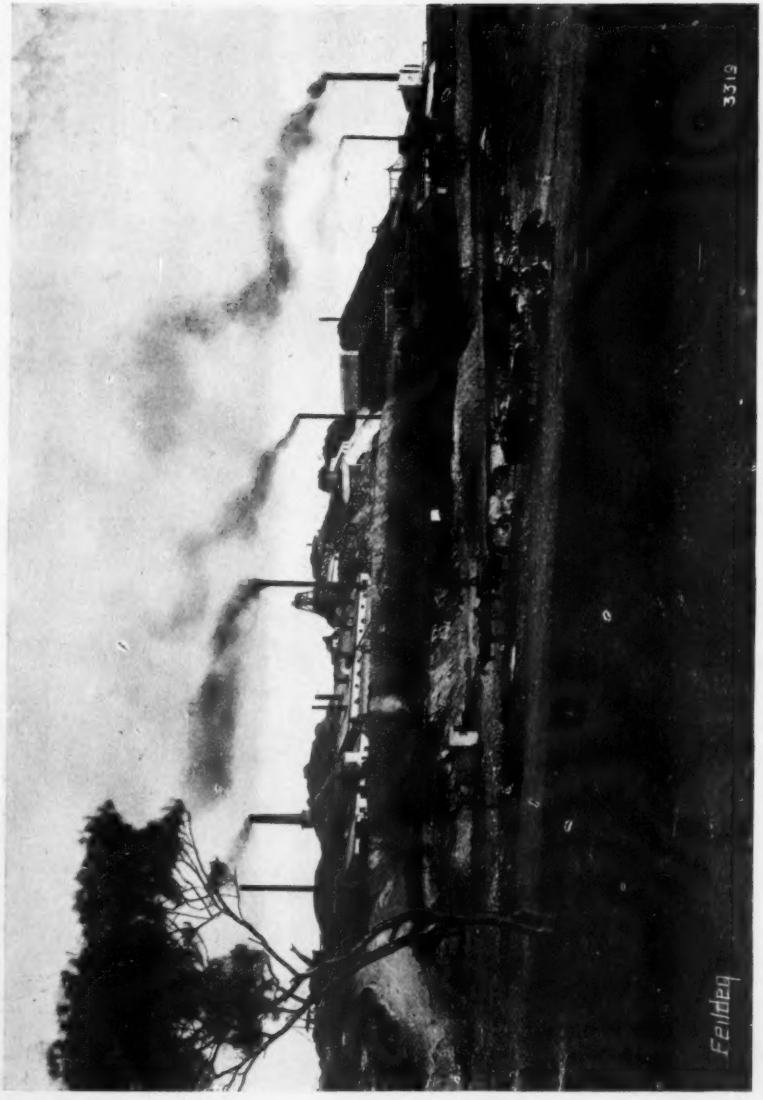
HISTORY.

The man who set the ball rolling, eighteen years ago, was Charles Rasp, a boundary rider on the Mount Gipps station, whose confines included the present site of the mines. He became possessed with the idea that the great mass of rock projecting above the plain, which must have attracted his attention so often, was rich in tin. In 1883 he threw up his employment on the station, and pegged out a mineral claim. In conjunction with the manager of the station, and five other station hands, he formed a small company, each putting £70 into the venture. They obtained a lease of the seven 40-acre blocks on the line of outcrop, numbered 10 to 16, the same ground which has since yielded wealth to the value of many million pounds sterling. But the first efforts were not successful. No tin was found, and for a whole year the work was continued without the discovery of anything valuable. At last a pocket of rich silver ore was met with in a trial shaft at a depth of 100 ft. Other rich pockets were found at other points on the property, one find of kaolin, weighing 46 tons, yielding as much as 35,000 ozs. of silver. The kaolin is generally richer in silver than are the other constituents of the lode.

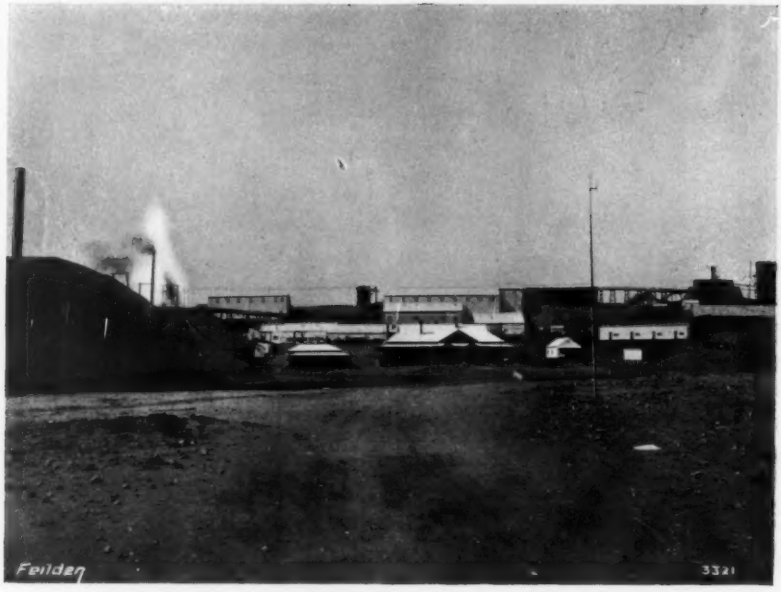
It seems to have acted as a filter on the argentiferous solutions passing through it, and to have retained the silver.

FINANCIAL RESULTS.

The value of the ground being proved, in August, 1885, the Broken Hill Proprietary Co. was formed. It began with an available capital of only £15,000. Its present paid-up capital is £384,000 in 960,000 shares of 8*s.* each. Up to May Day, 1900, it has paid to its shareholders, in dividends and cash bonuses, £7,736,000, and in addition £1,744,000 in shares in subsidiary companies, making a total of £9,480,000. It has spent on plant £1,136,672, and it possesses a reserve fund of £125,000, invested in safe securities. It has raised over 5,000,000 tons of crude ore, yet its present reserve of ore in sight is estimated to be nearly as much—viz. 4,568,000 tons. In the year 1899 its output was 412,298 tons of ore, the estimated gross value of its product £1,415,017, and it gave employment to 2,399 men at the mine and 1,335 at its Port Pirie Smelting Works. For the same year the total output of the Broken Hill



GENERAL VIEW OF THE BROKEN HILL PROPRIETARY COMPANY'S MINE



VIEW SHOWING SOME OF THE SURFACE WORKS OF THE BROKEN HILL PROPRIETARY COMPANY'S MINE.

mines, including that of the parent Company already given, was 1,262,107 tons of ore, the estimated value of the exported product £4,947,072, and the number of men employed 6,910. These figures, which are taken from the Annual Mining Report of the New South Wales Department of Mines, convey some idea of the importance of Broken Hill as a mining centre.

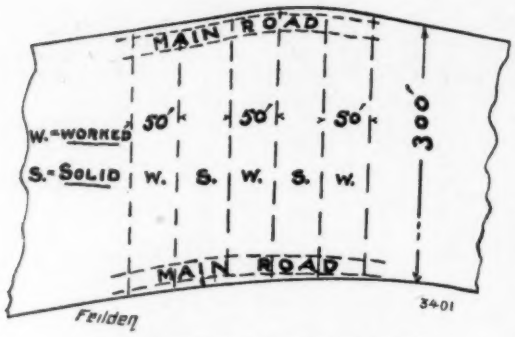
GEOLOGICAL.

Broken Hill forms part of the Barrier Ranges Mineral District, an area about 70 miles long and 30 miles broad, situated on the southern border of the waterless region in the centre of Australia. It consists of ranges of low hills of palæozoic rocks—schists, slates, and conglomerates—rising from plains covered with tertiary and recent deposits. The Broken Hill lode used to be considered a true fissure lode, but investigations in 1892 by Mr. E. F. Pittman, the Government Geologist of New South Wales, and Mr. J. B. Jaquet, the Geological Surveyor, showed that it does not cut across the bedded strata, but is interbedded with them. In conformity with the strata, it takes the form of an anticline. The outcrop forms the ridge of the anticline, and the two legs, dividing lower down, at different depths in the different mines, follow the inclination of the strata to the east and to the west. Lodes of this kind occur in the Bendigo goldfield in Victoria, and are there called "saddle" lodes. The legs of the "saddles" at Bendigo always thin out and disappear in depth, but other "saddles" are found perpendicularly below the first at varying intervals of depth. At Broken Hill the eastern leg of the lode has pinched out and disappeared, but the other has been proved to a depth of 1,400 ft. at a shaft belonging to the Block 10 Co.'s mine. This is the greatest depth yet reached. The width of the lode at this depth is 20 ft., but only about 6 ft. of it is good ore. The lode is very irregular in width

and in outline. It reaches its greatest thickness of 300 ft. at the Central mine of the Sulphide Corporation, Ltd. At the British Broken Hill Proprietary mine the width runs from 60 ft. to 80 ft. At the Broken Hill Proprietary the average width from the surface to a depth of 1,000 ft. is about 80 ft. As to the nature of the country rock, to quote from Mr. Pittman's report, it consists principally of crystalline gneisses passing into banded quartzites, micaceous and hornblendic schists, and garnetiferous sandstones. Owing to the highly altered character of these rocks, and the consequent absence of organic remains, it is difficult to determine their exact age, but they were considered by the late Mr. C. S. Wilkinson, F.G.S., to be at least Lower Silurian, and probably older. There are no dolerites in the neighbourhood of the mines, but intrusive dykes of highly basic diorite are seen extending along both sides of the hill, and more or less parallel to it. Broken Hill itself is composed of an anticline, the highest part of the ridge being occupied by the outcrop of the lode—a mass of manganiferous iron ore which has withstood denudation by reason of its hardness and compactness—whilst on the eastern and western slopes of the hill the gneissic rocks are seen to be dipping east and west respectively."

Below the manganiferous ironstone cap the contents of the lode have been oxidised by atmospheric influences to a depth of 350 ft. or thereabouts, varying much at different points. At lower depths the ores are chiefly sulphides of lead and zinc. In the oxidised portion, the sulphur and also the zinc have been removed. The mines are a rich hunting ground for collectors of mineral specimens. In the Proprietary Co.'s museum may be seen good specimens of iodyrite (AgI), embolite (AgClBr), native copper, and of many ores of copper of lead and of zinc. Some of the native copper, with its delicate and leaf-like structure, and the carbonate of lead showing the elaborate arrangement of its crystals,

VIEW OF THE CENTRAL MINE, BROKEN HILL, BELONGING TO THE SULPHIDE CORPORATION, LIMITED.



SYSTEM OF ORE-GETTING IN ALTERNATE BLOCKS.

are singularly beautiful, and there are some splendid specimens of both in the famous collection of Mr. Aldridge at Broken Hill. Some rare minerals have been found, such as sternbergerite, a double sulphide of iron and silver, and marshite (iodide of copper), so called after Mr. C. W. Marsh, who discovered it.

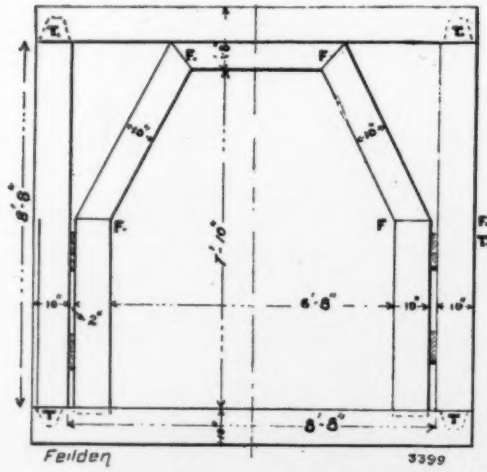
ORE-GETTING AND METHODS OF SUPPORT.

In getting the upper part of the lode at its outcrop and near the surface, the Proprietary Co. has adopted the quarrying or open cut system on a large scale. Mr. Alex. Stewart, the late general manager, had special experience of this system at the Tharsis Co.'s copper mines in Spain before coming to Broken Hill. At the last half-yearly meeting the chairman stated that up to date "3,250,000 cub. yds. of spoil, or waste, have been removed from this work (the open-cut) and 250,000 tons of ore extracted." The figures for the six months ended May 31st, 1900, were: Ore, 55,672 tons; waste, 231,255 cub. yds. A sufficient batter has to be given to the sides of the cut to make it safe for those working below, and this requires the removal of a considerable mass of waste material, but this is all utilised for filling up the excavations underground. At the time of the writer's visit in 1898, the open cut had reached a depth of 150 ft. Most of this work is done by contract, and the price varies from 1*s.* 6*d.* to 5*s.* per cubic yard. The ore and waste material are hauled up inclined planes by stationary engines, and there are also in use one or two aërial wire-rope tramways.

Shafts are sunk vertically in the country rock, and crosscuts driven to cut the lode at vertical intervals of 100 ft.

Most of the development work is now being carried on at the 600-ft. to 800-ft. levels, varying in the different mines.

Experience has shown that the chief dangers to be guarded against in the underground mining of this huge ore body are "creeps"—extensive movements of the strata—which on more than one occasion have caused great damage and loss in the Broken Hill mines, and fires, of which also there have been serious instances. This has led to the general practice of



TIMBER FRAME USED FOR SUPPORTING MAIN ROADS AT BROKEN HILL PROPRIETARY MINES.

filling up entirely all excavations with rubbish, commonly termed "mullock," as soon as possible after the removal of the ore.

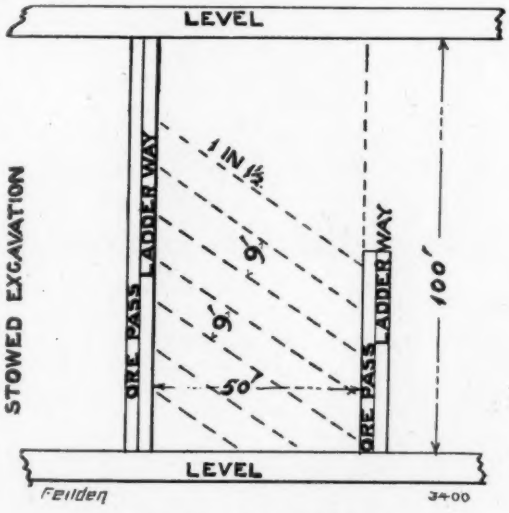
In his report for 1899 the Mines Inspector states that the quantity of mullock-filling put into depleted stopes in the Broken Hill mines in the year amounted to 279,448 cub. yds.

Mine timber is an important item in the expenditure. At the Proprietary Co.'s mine it cost during the 12 months ended November 30, 1900, £29,582, on an extraction of 399,853 tons of ore, equal to 1*s.* 5·75*d.* per ton, which is only the cost of the material, and does not include the cost of labour in setting it. This tonnage is the portion got by underground mining; 126,085 tons of ore besides were obtained during the same period from the open-cut.

Nearly all the timber used is Oregon pine, 10 ins. square, imported direct, sawn as required.

The sketch on page 396 shows the ordinary method at the Proprietary Co.'s mine of timbering the main roads where width is required for a double line of truck way. These sets are put in at intervals of about a yard. The sides are boarded with planks 10 ins. by 4 ins., set 5 ins. apart, to keep back the mullock, with which all the surrounding space is stowed. The roof is close boarded. This timbering has to stand the whole weight of 100 ft. of stowing up to the level above it, combined with the pressure of the strata. The ground at each side of the level is removed to the full width of the lode, and the floor laid with planks 10 ins. by 4 ins., on which the mullock subsequently rests. The ore body is got in horizontal slices 7 ft. high, the excavation being stowed with rubbish as it proceeds. A passage for the ore and a ladder way for the men are kept through the stowed space. Where the ground is very hard little timbering is required during this operation of stoping. In wide stoping the roof is sometimes supported by what are called "bulkheads," or the "pigsty" system. Six-ft. balks, 10 ins. square, are built up two-and-two crosswise, from floor to roof, like a pillar of "chocks" in a coal mine. Next the roof small pieces of timber are inserted, and by knocking out these the pile is loosened, and the timber can be removed before the place is stowed.

Where the ground is soft the whole excavation is timbered with square-set timbering, 6 ft. by 5 ft. by 7 ft. high from floor to floor, each floor being laid with planks, on which the men stand, and kept close up to the face. The planks are recovered, but the legs and caps and struts are left buried in the mullock with which the whole space is filled.



SYSTEM OF ORE-GETTING BY SLOPING STOPES.

In ground of medium hardness, where little or no blasting is required, a system of sloping stopes has been adopted by the Proprietary Co. (see above). They are driven downwards from one level to that below, on an inclination of about 1 in 1½. This allows the ore to slide downwards towards the level below, where it is filled

SURFACE PLANT, BROKEN HILL PROPRIETARY COMPANY.

into trucks, and also permits of the ready stowing of the excavation with mullock from above. The stopes are made 9 ft. in height, and in width from 10 ft. to 25 ft., according to the nature of the ground; on the average about 20 ft. The roof is supported during the process of excavation by props of Oregon pine 10 ins. square at top end tapered to 8 ins. square at the bottom, with "caps" or "lids." The tapered shape enables them to be withdrawn more easily from the mullock. To facilitate their recovery a hole is bored through each prop, near its upper end, through which an iron rod can be passed. The floor of each stope is laid with planks to keep the ore clean, and to form a smooth surface for its slide downwards. These planks are removed before the mullock is loaded in. The side of each stope next the unworked ore is lined with laths 2 ins. thick by 5 ins. wide, nailed to long uprights 10 ins. by 4 ins., at intervals of 5 ins. This is sufficient to keep back the mullock. The ore-pass and ladder-way are built up as the stoping proceeds. This system has manifest advantages in the utilisation of the natural force of gravity for moving the ore and the mullock, and in the recovery of the timber. In comparison with the square-set timber system, the saving must be great.

At the Central Mine of the Sulphide Corporation Co., where the lode attains the great width of 300 ft., Mr. Courtney, the general manager, has introduced a system of working it in blocks across the lode (page 396), 50 ft. of solid ground being left for a time between 50-ft. blocks of workings on either side. This reduces the risks of creep and of fire, the two dangerous possibilities to be guarded against.

Drives are made through the solid blocks, one at each side of the lode-

These are sometimes widened out to 18 ft., but the rest of the block is left standing until the adjacent blocks have been entirely removed. The system of working is by horizontal stoping. Over the whole of the lower floor, 50 ft. by 300 ft. at each level, square-set timbering is put in and is left standing. Above this the whole excavation is stowed with mullock as the stoping proceeds, and little timber is used except at the sides next the two walls of the lode. Here one set of the square timbering is carried up continuously from one level to the other. This maintains two open roads through the block when the adjacent solid blocks come to be worked.

A drawback to this system of blocks is that the making of the roads through the solid blocks occupies time and money without much return in ore for a while.

There are, then, in vogue five distinct methods of working the Broken Hill lode—

(1) By open cut from the surface.
(2) Where the ground is very hard, by horizontal stoping with refilling of the excavation.
(3) Where the ground is very soft, by horizontal stoping with square-set timbering and refilling.
(4) Where the ground is of medium hardness, by sloping stopes and refilling.
(5) Where the lode is very wide, by the block system.

WATER.

There is little water in the Broken Hill mines, and they are free from this serious obstacle to economical mining. About Broken Hill, the difficulty is to get water rather than to get rid of it. In the last half-yearly Working Account of the Proprietary Co., £7,065 13*s.* 1*d.* appears as the payment for water. In the previous half-year it amounted to £8,253 8*s.* 6*d.* At their Port Pirie Smelting Works they

THE OPEN CUT, BROKEN HILL PROPRIETARY COMPANY.

SQUARE-SET TIMBERING AT 500 FT.

were paying the South Australian Government 6*s.* per 1,000 gals. for water, but this has been reduced recently to 2*s.* The local water company at Broken Hill charges 5*s.* per 1,000 gals. During the last five or six years, the annual rainfall has averaged about 6 ins.

At its Port Pirie Works, the Company has erected a salt water condensing plant, which is capable of yielding 7,000 to 10,000 gals. an hour, but the cost was said to be 7*s.* per 1,000 gals. The works stand on the shores of Spencer Gulf.

FIRE IN A BLOCK.

LABOUR AND WAGES.

The miner's shift is eight hours. Six men usually share together, and work two in a shift, one pair following the other. Most of the mines work continuously three shifts in the twenty-four hours, from midnight Sunday to midnight Saturday. The miner's datal wage is 9*s.* per eight-hour shift. If employed on contract work, he expects to make 11*s.* His average weekly wage may be put at £2 10*s.* Truckers get 7*s.* 6*d.*; boys get 5*s.* There is a difficulty in obtaining men, owing to the out-of-the-way position of the place and the trying climate, and also perhaps to the risk of lead poisoning. In 1895 a Lead-poisoning Act—containing regulations about bathing, changing clothes, etc.—came into force, which has been beneficial, judging from the following figures. In 1895 there were 89 cases in a total of 4,297 men employed; that is, 2·07 per cent.; and in 1899 only 13 out of 6,910 men, equal to ·188 per cent. It should be mentioned that in the latter part of 1897 the Proprietary Company shut down its lead smelters at Broken Hill, and commenced operations at its new works at Port Pirie on the coast of South Australia at the top of Spencer Gulf. This change much reduced the danger to health at Broken Hill.

As regards accidents, the average figures

per year for the four years 1896 to 1899 inclusive are—

	Underground.	Surface.	Total.
Fatal accidents ...	13	2	15
Serious do. ...	15	8	23
Minor do. ...	28	14	42
	56	24	80

This gives a death-rate per 1,000 men employed, which is very small compared with that due to accidents in coal mines.

COST OF MINING.

The cost of mining—that is, of getting the ore and delivering it into the bins on the surface, including all wage charges, such as fuel and machinery—runs about 10*s*. per ton. About 60 per cent. of this goes in wages.

The cost of cutting roads 7 ft. high by 5 ft. to 7 ft. wide, varies from £1 to £5 a lineal foot, according to the nature of the stone. The employers usually supply machine rock drills and tools, and the workmen pay for the explosive used. The rate of progress of some of these stone drifts where the stone is hard is only 4 ft. in a week.

At the lower levels—600 ft. and 700 ft. —where development work is now proceeding, the stone is harder, owing largely, it seems, to the presence of rhodonite (garnetiferous sandstone). Drilling machines driven by compressed air are found to be necessary, and are being increasingly adopted. The Proprietary Company have erected recently a new air-compressing plant of a capacity of 96 machine drills. Compressed air is also in use as the motive power for hauling and hoisting winches underground in a few instances.

All the mines are lighted on the surface by electricity, but it has not been found economical to extend it below to the lighting of the levels, nor has it been adopted for power transmission.

ORE TREATMENT.

The metallurgical treatment of the oxidised ores, which are found within a depth of 200 ft. to 500 ft. from the surface, presents no exceptional difficulties.

On the Proprietary Company's take there is a considerable variety in these oxidised ores. They have been classified into :—

(*a*) Ores of lead (chiefly carbonate of lead), containing some silver.
(*b*) Silicious kaolin ores, rich in silver, with a small quantity of lead.
(*c*) Silicious iron ores of medium grade, both in lead and silver.
(*d*) Flux iron ores (chiefly manganiferous iron ores), with some lead but very little silver.

Very little zinc is found amongst the oxidised ores, not sufficient to affect the process of smelting.

SMELTING.

These different ores, some rich in silver and others in lead, can be mixed together so as to make, with the addition of limestone and fuel, a suitable charge for the smelting furnace. In the operation of smelting, the lead and the silver are liberated from their ores, and having an affinity for each other, they come together, and, owing to the weight of the lead, they fall to the bottom of the furnace, whence they are run off in a molten state, and solidified in the form of bars.

Latterly, the supplies of flux iron ores on the Proprietary Company's property have been dwindling, and the Company has obtained from the South Australian Government a lease of 300 or 400 acres of rich ironstone-bearing ground at Iron Knob in South Australia. The lease is for forty-two years, and the rent is 1*s*. per acre per year. The property is now being developed, and a railway, at an estimated cost of £80,000, is being made to connect it with the coast, whence the ironstone will be conveyed by steamer to Port Pirie. The accounts of the Company show an expenditure of £42,000 for ironstone during the year ended November 30th last, of £25,880 for limestone, and of £99,312 for coke. The Company is now erecting coke ovens at Bellambi, in New South Wales, and, by supplying thus its own requirements, will effect, no doubt, a large saving. Hitherto the coke has been imported from Europe. When the writer visited Port Pirie in 1898, a large stock of coke from Westphalia — some

BULKHEAD TIMBERING: 300-FEET LEVEL, BRITISH BROKEN HILL COMPANY

20,000 tons—was lying on the wharves. It cost 44*s.* 6*d.* a ton, and was preferred, after trial, to Durham and Welsh coke.

SMELTING FURNACES AT PORT PIRIE.

The new smelting furnaces at Port Pirie, which were started early in 1898, are very large—120 ton furnaces—20 ft. 6 ins. in height and 18 ft. by 5 ft. at the tuyères. Each charge weighs 5,000 lbs., and contains about 12 per cent. of coke, with the various ores and fluxes. It has been found economical to buy gold ores from the West Australian gold mines to smelt in these furnaces. The process of smelting occupies about twelve hours. The silver-lead bullion is run off in front of the furnace at the lowest level. Higher up, and at the side, is an outlet for the copper* matte containing silver, and higher up again is the outlet for the slag.

The furnaces are water-jacketed round the smelting zone. Air is introduced at a pressure of 15 ozs. per square inch. The blowers, of which there is one for each furnace, are Baker's rotary pressure blowers, made by an American firm. The air is conveyed from the blowers, which are placed together under one roof, in a metal pipe 5 feet in diameter, which extends along the whole line of the eleven furnaces.

CHLORIDISING AND LEACHING.

Some portions of the lode contain very little lead, but a good proportion of silver, running from 12 ozs. to 25 ozs. per ton, chiefly in the form of the iodide or bromide or chloro-bromide of silver. This, being unsuitable for smelting, is treated by chloridising and leaching.

The ore is first crushed, and then put into revolving cylinder furnaces with a charge of about 6 per cent. of its own weight of common salt—sodium chloride. This converts the silver into chloride of silver, in which form it is amenable to the subsequent leaching process.

The roasted ore is loaded into trucks and conveyed to the leaching works, where it is put into vats holding 40 or 50 tons. To extract any lead there may be, it is first subjected to the action of hot water. This dissolves out some of the lead, and the liquor is run into other vats containing scrap-iron, on which the lead is precipitated.

After this washing with hot water, a solution of hyposulphite of soda is introduced into the vat. This dissolves the chloride of silver, and also any lead remaining. The resulting solution is drawn off from the bottom of the vat and run into a smaller vat, where the lead is converted into carbonate of lead by the introduction of carbonate of soda, and the silver is precipitated as sulphide of silver by the addition of sulphide of sodium. The sulphide of silver is compressed into cakes, which are roasted to get rid of the sulphur.

The quantity of chemicals used per ton of ore was stated to be:—

Hyposulphite of sodium	3·8 lbs.
Caustic soda	2·25 ,,
Sulphur	1·5 ,,
Carbonate of soda	21·0 ,,

SULPHIDE ORE.

Below the oxidised zone, the lode consists generally of an intimate admixture of particles of argentiferous galena and argentiferous blende, in a gangue composed largely of quartz and rhodonite. The mixed sulphide ore contains 7 to 50 % lead, 14 to 30 % zinc, and from 5 to 36 ozs. of silver per ton. Copper ores also occur, and some antimony and gold. The efficient treatment of this mixture of ores presents many difficulties. The first step is to separate the galena from the blende, and both from the worthless gangue. But the particles are so closely associated that ordinary concentration methods by mechanical means—that is by crushing and sizing and jigging, such as were tried at first—were found to be ineffectual, so much so that at one time it appeared as though success could be attained only by chemical methods.

CONCENTRATING METHODS.

But such improvements have been effected in the concentrating methods that now satisfactory commercial results are secured by these means, though there is a large margin left for further improvement in the more perfect separation of the

* There is a good deal of copper ore in the lode.

blende and galena, and in the more complete extraction of all the valuable products in a marketable condition. The main point aimed at has been to obtain as large a proportion as possible of argentiferous lead concentrates. The ore is first put through three successive stages of crushing and sizing—(1) through Gates crushers, (2) breakers on the jaw principle, (3) Cornish rolls made of the hardest iron. Owing to the presence of rhodonite (silicate of manganese), the wear on these rolls is very great. The rhodonite too, being of similar specific gravity to zinc blende, is difficult to separate in the subsequent classifying process. Sizing takes place between each stage of crushing, first over grizzlies (bar screens) attached to the Gates crushers, and then over trommels—circular sieves—of decreasing apertures, successively in the second and final stage. It is crushed fine enough to pass through holes from $\frac{1}{10}$th to $\frac{1}{16}$th inch in diameter. Fine crushing is essential to the separation of the galena and the blende, but the fineness is limited by the resulting slimes, which increase in proportion to the fineness. Much of the silver is lost in the slimes. After crushing and sizing, the next process is classifying by jigging, which separates the particles according to their specific gravity. The jigs have five compartments. The following figures give some idea of the products thus obtained—

Containing per ton.	Lead.	Zinc.	Silver.
	per cent.	per cent.	ozs.
1st grade concentrates	60 to 70	8 to 10	25 to 30
2nd grade do.	45 to 55	15 to 20	20 to 25
Middlings	10 to 15	25 to 35	10 to 15
Tailings	6 to 10	10 to 20	5 to 10
Fine slimes	30 to 35	18 to 25	20 to 25

The products of the middle hutch, and also often of the 4th and 5th, are recrushed and rejigged to further separate the lead and zinc.

The slimes are treated on buddles and vanners: 4*s.* to 5*s.* a ton is an average cost of treatment in the concentrating mill.

ZINC CONCENTRATES.

The economical extraction of the zinc from the zinc concentrates has occupied many brains, and has been the subject of much experiment for some years past. Success is claimed for one or two processes, but as yet the mining companies, who are so keenly interested in the matter, have not been sufficiently satisfied to adopt any process. A satisfactory solution of this problem, which is highly probable, would largely increase the value of the Broken Hill Mines.

ROASTING.

Before being smelted the sulphide concentrates are roasted in Ropp furnaces. At the time of the writer's visit, three years ago, four of these furnaces had been erected at the Port Pirie Works. They were 160 ft. long, with four fires at each side. Coal is the fuel used, brought all the way from Newcastle, New South Wales. The Company's coal bill last year amounted to £84,528. This, of course, includes all coal used for boiler firing and other purposes.

REFINERY.

In the refinery the product of the smelting furnaces is separated into its valuable constituents. The first process is to eliminate the copper and the antimony. First the copper is separated in furnaces of the reverberatory type, termed "copper softeners." The residue is run into adjacent furnaces of the same construction, where the antimony combined with other substances comes to the surface. This is skimmed off, and taken first to the antimony drossing furnace, and then the residue to a smelting furnace with air-blast. The product is antimonial metal, composed of 22 to 25 per cent. of antimony, about 2 ozs. per ton of silver, and the remainder lead, with a tiny proportion of arsenic and copper.

The gold-silver-lead product now left is put into desilverising zinc kettles—basins about 9 ft. in diameter and 4 ft. deep in the centre—holding 44 tons, heated by fires below. Zinc is added to the molten mass, and the whole agitated by steam introduced at the bottom of the kettle, and also by stirring with long ladles.

Here the gold and the silver, attracted to the zinc, rise to the surface, and are removed. The lead residue is run into lead-refining furnaces placed on a lower level. The product is lead of almost

absolute purity—999·98 per 1,000—the balance being zinc.

The silver-zinc product from the zinc kettles is treated in retort furnaces, where the zinc is distilled off and condensed in receivers. The silver residue, with which is mixed a little lead, is put into cupel furnaces, in which the lead is thrown down as oxide of lead (litharge) and the pure silver is run off into bars. It goes through yet another melting in small furnaces, to allow of the addition of a small alloy of copper, as required by the purchasers. The product is run into moulds, its composition being about 996 per 1,000 silver, and the rest copper.

There is a parting plant on the Gutzkow system for treating the Doré bars obtained from the zinc kettles, to separate the gold from the silver.

According to the statement of the chairman of the Broken Hill Proprietary Company at its half-yearly General Meeting at Melbourne, on January 25th, 1901, 123,842 tons of ore, concentrates, etc., were put through the smelters at Port Pirie during the half-year. To treat this quantity of ore, 119,891 tons of fluxes and fuels were used. The refinery treated 22,553 tons of silver-lead bullion, which produced—fine silver, 2,946,144 ozs.; gold, 3,076 ozs.; soft lead, 21,088 tons; antimonial lead, 414 tons; and copper, 254 tons.

It may be stated roughly that of the ore raised from the mines, about one-fifth is valuable, and out of this about 70 per cent. of the lead, and 45 to 50 per cent. of the silver are obtained. As years go on and improvements are introduced, it is probable that a larger extraction will be achieved, and that to the other marketable products will be added zinc.

H J Bulman

The Manufacture of Portland Cement.

A Visit to the Works of Martin, Earle & Co., Ltd., Rochester.

By OUR SPECIAL COMMISSIONER.

To the traveller with an eye to the picturesque, the aspect of Rochester from the northern bank of the Medway is distinctly pleasing. From an artistic point of view there are various features that might be omitted with advantage. But artists must take things as they are, and it is possible that even the cement-works chimneys of the Medway may form an excellent foil for the ancient castle and cathedral of Rochester. Standing on the hill over Wickham, the wayfarer may observe, on one side of the slowly moving waters, the well-preserved relics of mediæval times, and on the other the evidences of modern industrial enterprise. The time-worn keep is no longer required for the purpose of national defence, and picturesque repose is now its chief merit. On the opposite shore, the works of Messrs. Martin, Earle & Co., the most important firm in the Portland Cement trade outside the cement "combine," serve to typify one phase of national defence in the present day, the protection of home industries against foreign encroachments.

These works, to which attention will now be particularly directed, were established in 1894 upon the site of a practically obsolete cement factory.

Situated in the cement hamlet of Wickham, about one mile from the town of Strood, the works occupy a site extending for nearly a mile along the waterside, and back into the chalk hills beyond the two railway lines. By reference to Fig. 1, it will be seen that the cement works of the present company are immediately in front of the quarries, while next to these are the extension works now nearing completion. A piece of meadow-land beyond is available for further contemplated extensions, and beyond this again are the engineering works and foundry. The present wharf frontage is fully half-a-mile in length, and affords accommodation for over fifty barges and sailing vessels at a time (Fig. 9).

In presenting to our readers some impressions of a recent visit to the establishment, it will be convenient to deal first with the original cement works, a general view of which will be found in Fig. 2. On entering the main office-building, which is appropriately of cement construction, the visitor cannot fail to be impressed by the extremely roomy nature of the accommodation. Despite the activity prevalent in every part of the works, there is an entire absence of confusion, and the systematic manner in which all operations are conducted denotes thorough organisation, such as that evidenced by the ceaseless revolution of some huge engine; whilst its practical effect is the production of between 2,500 and 3,000 tons of cement per week, an output that will be increased to from 5,000 to 6,000 tons in the same time, on the completion of the extension works now in progress.

Portland Cement, which is the staple industrial product of Messrs. Martin, Earle & Co., was first made in this country about the year 1843, and its name has no geographical signification, being merely intended by the originator to suggest a resemblance between the hardened mortar made of the cement and the well-known stone yielded by the quarries of Portland. Natural cement, similar to that originally patented by Mr. Parker in the year 1796, is still manufactured from the argillo-calcareous nodules, or septaria, found in the Isle of Sheppey and elsewhere. The product, known as Roman cement, weighs less, has less strength, and generally sets more rapidly than the artificial variety of cement with which we are now concerned. As manufactured in the vicinity of London,

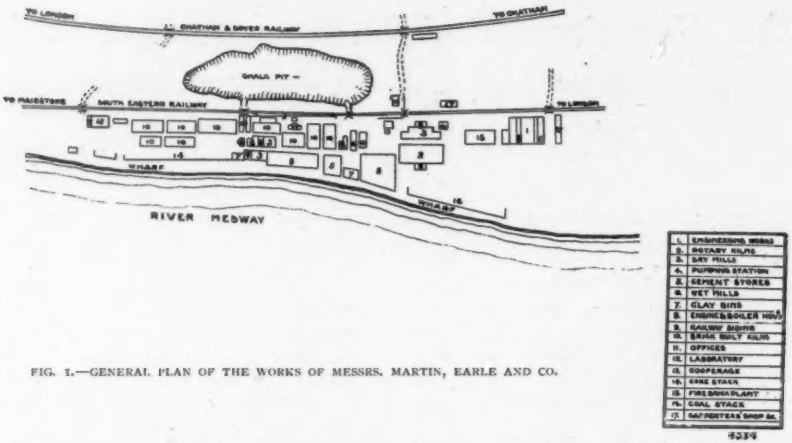


FIG. 1.—GENERAL PLAN OF THE WORKS OF MESSRS. MARTIN, EARLE AND CO.

Portland cement is a preparation in which the ingredients are chalk, quarried from the upper strata of that formation, and clay, dug from the alluvial formations of the Thames or Medway. The process of manufacture is particularly simple; for these ingredients, after preparatory treatment, have merely to be mixed in proper proportions, calcined, and ground. Yet, if satisfactory results are to be ensured, the greatest care must be exercised throughout the whole of the processes, under the supervision of chemical and other experts. As the Wickham works are situated partly on, and partly at the foot of, the chalk hills, and at the very edge of the river Medway, every convenience exists for the economical supply and handling of raw materials. The chalk quarries, of which Fig. 3 is a photographic view, are connected with the works by a cable trolley track, passing through a short tunnel beneath the South-Eastern main line, and a huge amphitheatre extending at one point as far as the Chatham and Dover Railway, represents the output of cement during the past eight years. Already the cutting through which the South-Eastern Railway formerly passed, has been swallowed up by the insatiable kilns, and one side of the Chatham and Dover cutting is in process of demolition. The next development is to be the driving of a tunnel beneath the latter railway, so that chalk may be taken from the spacious freehold lands beyond. The lavish supplies of mud which characterise the upper reaches of the Medway are unfortunately useless for cement manufacture, and the argillaceous material necessary is furnished from marsh lands in the neighbourhood.

The bringing in of these materials constitutes the first stage in the manufacturing process, and the second is to mix the ingredients in certain defined proportions, and to treat them in what are termed "wash-mills." As a rule, it is the object of the manufacturer to effect a mixture containing approximately 76 per cent. of calcium carbonate and 20 per cent. aluminium silicate, the remainder of the mixture consisting of various substances present in the chalk and clay. At Wickham, the chalk contains over 98 per cent. of calcium carbonate, but the proportion is more or less variable, and the latter remark applies to the clay. Hence, chemical examination is necessary for the guidance of those engaged in the preliminary stage of manufacture. The wash-mills mentioned above are very much like grinding mills in appearance. Each of them consists of a brick chamber, about 16 ft. in diameter and by 12 ft. deep, the upper portion projecting about 3 ft. above the surface of the ground; in the centre is a vertical shaft actuated through bevel gear by a horizontal line

of shafting, extending across a series of wash-mills. At the lower end of the vertical shaft four arms are attached, each carrying a massive cast-iron plate having projections on the under surface; and at one point near the bottom of the brick chamber is a cast-iron grating. When the chalk and clay have been tipped into the wash-mill they are thoroughly churned up by the revolving plates, or scrubbers, the process being aided by the addition of water, slowly trickling from a pipe projecting from the upper part of the chamber. As the process proceeds, the particles of chalk and clay are washed away from flint stones and coarse *débris* contained in the raw materials, and a portion of the liquid mixture is washed through the grating at every revolution of the scrubbers. Solid lumps of chalk, and stodgy masses of clay are gradually reduced, until nothing is left but stones and other intractable materials. These are cleared away at intervals and sold for building and other purposes. The mixture leaving the wash-mills is known in the trade as "slurry." The slurry discharging from the wash-mills gravitates to elevators which raise it into a tank, whence it is fed into the wet mills and thoroughly ground, where any particles of chalk that may have escaped from the wash-mills are reduced, and a thoroughly homogeneous slurry is produced. From the wet mills, the slurry is discharged into "mixers," consisting of large becks, about 14 ft. in diameter, fitted with stirring mechanism for the purpose of preventing the deposition of suspended matter. The mixers are erected in sheds adjacent to the wash-mills and wet-mills, and from them the slurry is pumped through iron pipes to the kilns. In order that the process may be continuous, the mixers are duplicated, and the discharge pipe from the wet-mills is arranged so that either mixer can be served at will. As before stated, it is very important that the correct proportions of calcium carbonate and aluminium silicate should exist in the slurry before it is transferred to the kilns. Therefore chemical examination is made of each

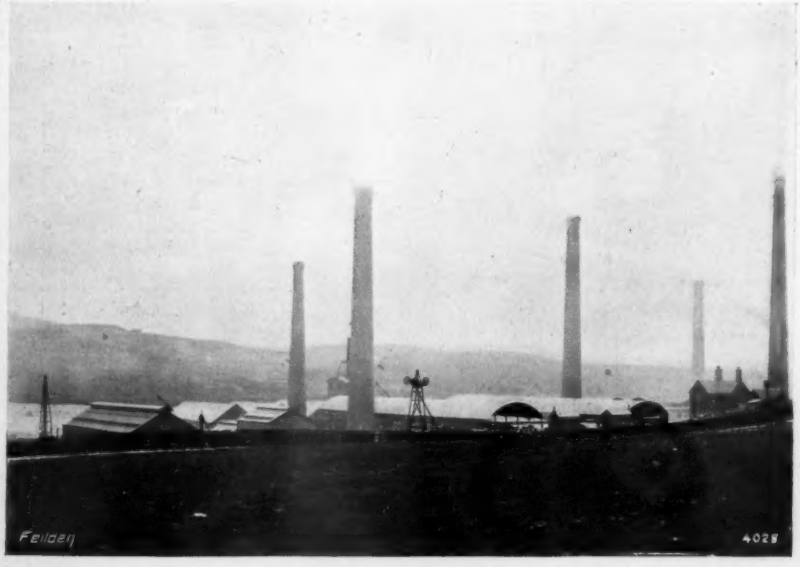


FIG. 2.—A VIEW OF THE ORIGINAL CEMENT WORKS.

FIG. 3.—THE CHALK QUARRIES.

batch, and, if necessary, its constitution is modified by the admixture of poor or richer slurry, as the case may be. Steam pumps in the mixer-shed are arranged so that slurry may be drawn from either mixer. At the Wickham works, wash-mills and mixers stand in a fairly central position for the convenient supply of the kilns. Following the delivery pipes, we come to a long street of furnaces where the third and fourth stages of manufacture are conducted. Upwards of 95 kilns are in operation at the works, some of them being shown in Fig. 4. But to make matters clear, we must explain briefly the construction of a furnace. The kiln proper, which holds over 30 tons of dried slurry, is of cylindrical form, with an opening in the upper portion for the delivery of fuel from an elevated gangway, and another opening at the bottom for withdrawal of calcined material. Behind the kiln proper two horizontal flues extend in the form of tunnels, about 4 ft. high by 10 ft. wide to the chimney. Slurry is delivered upon the floor of these tunnels to a depth of about 12 ins., and is prevented from running into the kiln by a low wall or "dam" temporarily built of clay. Here the slurry parts with the greater part of its moisture under the influence of the hot gases from the furnace, and on its transition from the liquid to the solid state the material acquires the new name of "slip." The term is not altogether accurate, for "slip," or alternatively, slop, is generally understood to designate potter's clay or kindred material reduced to a semi-fluid condition by the application of water—exactly the reverse of the process we have described. It would be more appropriate to distinguish sloppy "slurry" as slip, and the more solid "slip" as slurry; but then, nobody in his senses would try to alter time-hallowed trade expressions, and after all, it does not much matter whether they are quite correct or not. To return to our kiln, the reduction in the flue of "slurry" to "slip" is effected during the conversion, in the kiln, of a previous charge of slip into "clinker." Thus one fire serves two purposes. In charging a kiln, the first layer is a quantity of faggots, next comes a layer of gas coke, and above that are alternate strata of slip and coke, to the top of the kiln. The slip is shovelled in from the tunnel, and before the fire is lighted a fresh supply of slurry is run in to the tunnels and banked up by a dam as before mentioned, and the upper opening is closed by fire-bricks and clay, leaving only a small inspection hole, into which a convenient fragment of brick is loosely inserted. When the fire has burned completely out, all the coke has gone away in the form of gases, and nothing but cement clinker remains, the product of a kiln being about 25 tons in weight. One of the important processes in the manufacture of cement, and one of the most difficult to control, is calcination of the material to a sufficient degree, and yet without overburning. Underburnt clinker yields weak cement, and overburnt clinker yields an almost inert material. The ideal cement is produced by calcination at a temperature just below that which would cause vitrification, but it is extremely difficult to arrange that such a temperature shall be ensured in every part of a kiln. Consequently, it is often the case that part of the clinker is underburned, part is over-burned, and the remainder is correctly burned. A firm may have the finest raw materials at hand, the most modern plant, and the most scientific chemist, and yet be incapable of turning out a reliable product. There is no royal road to cement making, success depending very largely upon hard-earned experience, and the most painstaking attention to all the minutiæ of furnace management. That Messrs. Martin, Earle & Co. have succeeded in solving the problem, and are daily applying the solution in their works, is evidenced by the high esteem in which their cement is held by the various Governmental Departments, the London County Council, and other public authorities.

It is unfortunately the fact that many cements of foreign manufacture, are upon the market that ought never to be accepted without the most stringent examination, after which they would more frequently be rejected than at present. Even when the

greatest care has been exercised, a small portion of the clinker may be somewhat under-burned. This is readily detected by reason of its lighter colour, and at the Wickham works all such portions are carefully removed before the clinker is taken from the kiln. From the lower openings of the kilns, the calcined material is transported by a trolley system to the mill houses, where the clinker is reduced to almost impalpable powder in grinding

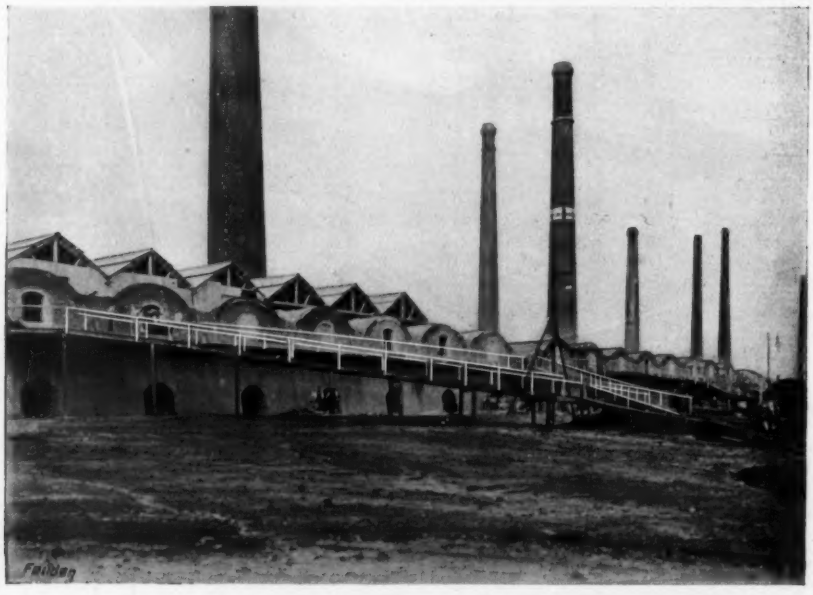


FIG. 4.—A GROUP OF KILNS: OLD STYLE.

mills of the well-known "Griffin" and other types; and the cement is finally packed into bags or barrels as may be preferred by purchasers. The main stores, in close proximity to the quayside, have a capacity of 10,000 tons, and from them cement is readily loaded up into vessels, whilst a railway siding affords means of communication with all parts of the country.

Before passing on to consider the other departments of the works, we must not omit to mention the testing laboratory. In addition to examination of the raw materials, the chemist is responsible for the conduct of tests upon all batches of cement manufactured, and an exact record of each is carefully preserved for future guidance as well as for reference in the unlikely event of complaints being made. Scientists have devoted much time to the invention of tests for Portland Cement, in the neat state, and mixed with sand forming mortar, and with agglomerate forming concrete. To refer to these, even briefly, would require far more space than we can now afford; and our attention will therefore be confined to the three chief characteristics into which enquiry is made at the laboratory attached to the Wickham works. Tests for soundness are of considerable importance, and the method followed is known as the hot-water test. It is made with a vessel containing water maintained at a temperature of about 115 degs. Fahr..

in which a small pat of cement allowed to "set" on a piece of glass is placed, for a period of twenty-four hours.

If, at the expiration of that time, the cement still adheres to the glass, and exhibits no cracks, it is considered to be sound. In some cases soundness is tested by the measurement of expansion. The "expansion test," as it is called, is effected by measuring the increase in length of a small bar of cement, or by measuring the increase of circumference of a smaller cylinder. Very delicate instruments, and the most careful manipulation are necessary in the test if the results are to be of service; and, for all ordinary purposes, the hot-water test is quite sufficient. Activity is the essential quality of cement, and is evidenced by solidification when dry cement is mixed with water. The ground clinker is merely a mixture of which the chief ingredients are calcium silicate, calcium aluminate, and calcium ferrate; but the addition of water sets up chemical action resulting in the formation of double hydrated silicates. Cements vary widely as to the rate and manner of setting, and knowledge upon these points is very necessary both to the user and the manufacturer. A very general opinion, fairly established by experimental records, is that quick-setting cements soon reach their maximum strength and then deteriorate; and that slow-setting cements possess greater initial strength and continue to improve in this respect with the lapse of time. Consequently, the user frequently specifies the required time of setting, and the manufacturer must be armed with data to enable him to comply with the necessary conditions. The test for activity is performed by making a pat of cement in a metal box, or in a ring placed on a glass slab; and the pat is then brought beneath a Vicat needle apparatus, by which the penetration of the needle can be read from an index moving over a graduated scale. By the adoption of definite standards, this device enables the operator to determine, upon a uniform basis, the initial and final setting-time of all tested samples.

Tests for tensile strength made at the laboratory of Messrs. Martin, Earle & Co., are generally conducted with neat cement, moulded in the form of briquettes and tested in the Adie machine. Taken alone, the neat cement test for tensile strength is not free from objections. The most important of these is that coarsely ground cements sometimes show greater strength than those that are more finely ground; although the latter, when mixed with the usual proportion of sand invariably exhibit the greater strength. The reason for this is, that a good cement will stand the addition of a certain proportion of inert matter without serious reduction of strength, and that the finely ground qualities will bear a much larger proportion of sand than the coarsely ground qualities. Hence, neat tests might put a premium on inadequate grinding, were it not for stipulations as to fineness. No doubt much benefit has been derived from the discovery that particles of cement too large to pass through a very fine sieve are practically inert, although if re-ground they become useful cement. The sieve is almost universally used for the measurement of fineness, but it cannot afford very exact results. More precise information can be obtained by the Goreham "flourometer," one of which we observed at Wickham; and this ingenious contrivance enables the operator to discover the exact proportion of impalpable powder existing in any given sample of cement. It must always be remembered that fineness is entirely a matter of economy, and the proper degree of fineness is attained when it becomes cheaper to buy additional cement than to pay for extra grinding. Fine cement can be produced by the use of soft, underburned clinker; by bolting the mill product through a sieve, and returning coarse particles to be re-ground; or by most thorough grinding in the first place. Messrs. Martin, Earle & Co. adopt the latter alternative, as may be judged from the fact that all the old-fashioned millstones have long since been displaced by the most modern types of grinding machinery. Tests of specific gravity for ascertaining the thoroughness of burning, and of chemical constitution for determining hydraulicity, complete the category

of work included in the laboratory; which, it will be seen, is of supreme importance to the manufacturer who is determined to secure the most satisfactory results at the least possible cost. Engineers may sometimes appear to be unduly troublesome in their requirements; but, after all, such stipulations tend to protect British cement from cheap and comparatively valueless foreign imitations. Architects and builders

that can be seen at a first glance is a range of buildings, including sheds, towers and elevators; in front of some of these structures are mysterious cylinders, supported on cement foundations, and looking very much like steam boilers of altogether disproportionate length. Beyond these and nearer to the riverside are more foundations of considerable extent, and areas covered with piling, evidently for

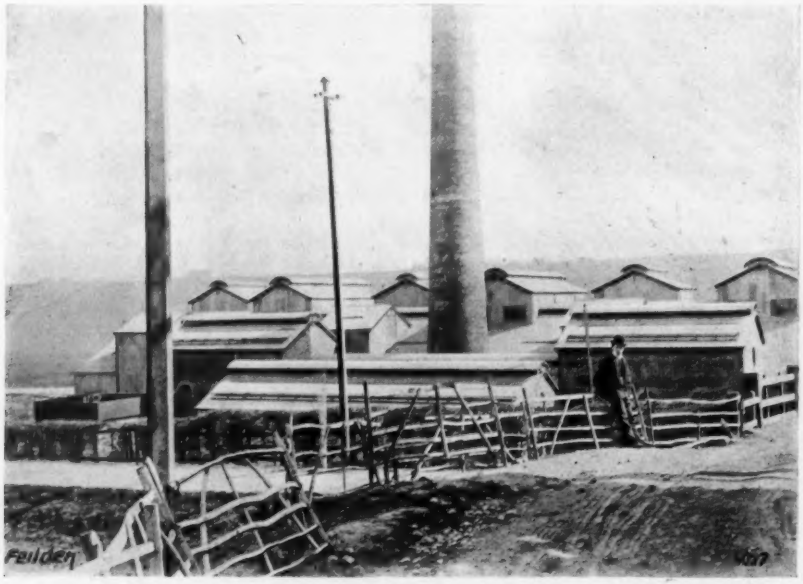


FIG. 5.—VIEW OF THE NEW WORKS, TAKEN FROM THE RAILWAY.

are by no means so exacting, and their complaisance contributes in no small measure to the encouragement of foreign cements.

We come now to the new works, at the present time rapidly nearing completion; a view of which, taken from the railway, is shown at Fig. 5. Here, it becomes evident to the observer, that the work of the engineer is fully equal in importance to that of the chemist. This conclusion may not be arrived at immediately, but it becomes inevitable when the exact scope of the new works is fully realised. All

the erection of additional structures, or heavy machinery. A little to one side a large building, of cement construction throughout, is approaching completion. Fig. 6 is an interior view of the new works.

In order to make clear what is being done, we must explain that the new, or more correctly, extension works are being erected and equipped with the object of applying the most modern methods to every detail of cement manufacture. The process will not differ essentially from that pursued in the original establishment, but

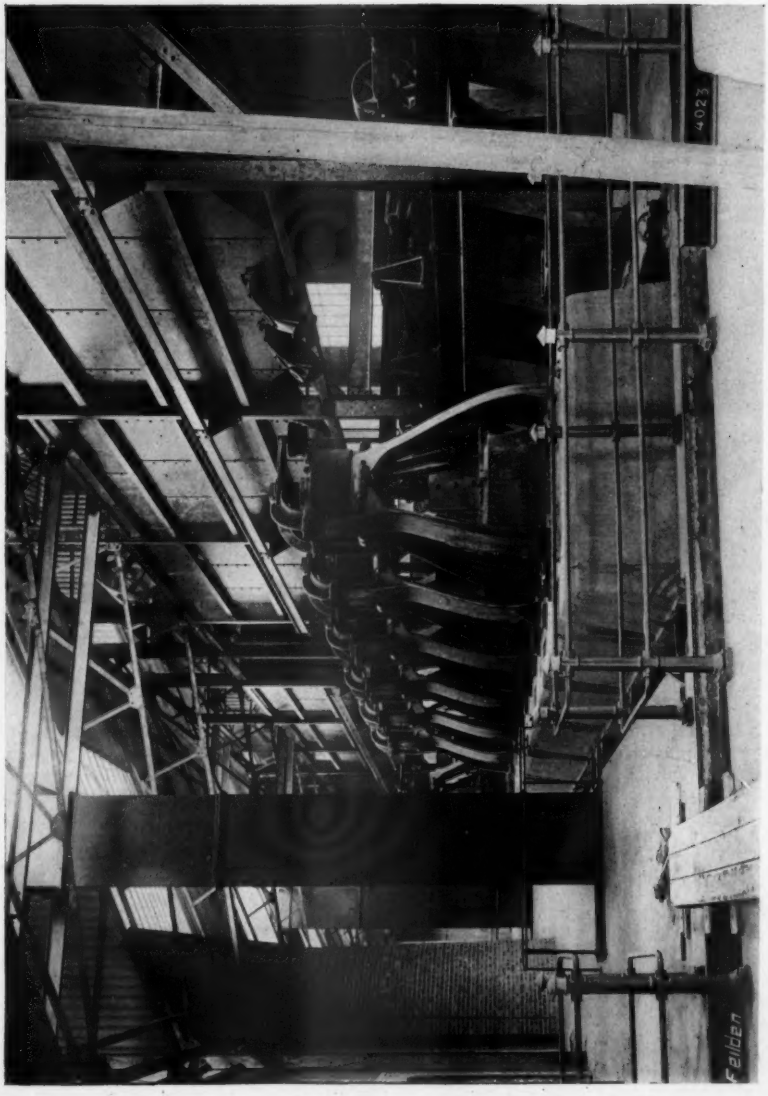


FIG. 6.—VIEW OF THE INTERIOR OF PORTION OF NEW WORKS, SHOWING BATTERY OF GRIFFIN MILLS.

it will be brought to perfection by the aid of improved machinery for preliminary treatment of the materials, and by the adoption of kilns that will yield more uniform and better results than those of the ordinary type. Moreover, the kilns will be suited for the consumption of fuel that is more readily obtained and more easily handled than gas-works coke, while conveying mechanism will largely take the place of hand labour.

In the improved process, raw material is brought down to "wash-mills," and there converted into "slurry" as previously described, but instead of being pumped to the kilns, without other preparation than that afforded by the old-fashioned wet-mills and mixing becks, it is transferred to grinding houses where the semi-fluid slurry is passed through compound mills of special design to be seen in Fig. 7, for the purpose of perfecting the mixture and at the same time of ensuring the absence of what is termed "free lime." After this operation, the slurry is pumped through cast-iron pipes to the kilns. These are of the rotary type, so largely used in the United States, but the kilns at the Wickham works embody various novel features which have been duly protected by patents. Previous attempts to introduce the rotary system of calcination into this country have not been remarkable for success. Messrs. Martin, Earle & Co., combining the experience gained by many years of cement making with the assistance furnished by the engineering department, have arrived at a form of rotary kiln giving surprisingly good results. This is not merely theory, for, after exhaustive experiments covering a period of over two years, a full-sized improved rotary apparatus was equipped on the works, and the cement produced was of far better quality than any hitherto known.

At the present no less than 16 rotary kilns are being built; but this is not all, for each of them is merely one link in a chain of connected operations. Fig. 8 shows the new kilns in course of erection; and, taking one of them as an example, we find it to consist of a riveted steel tube, some 90 ft. long × 6 ft. in diameter, lined inside with a peculiar form of basic brick, as to the composition of which Messrs. Martin, Earle & Co. are judiciously silent, although they do not hesitate to show a certificate setting forth that the new material was successfully tested in actual use to a temperature of 3,000 deg. Fahr. without injury.

The kiln is supported at intervals by cast-iron circumferential rings secured to the shell, the rings revolving on "idlers" running on shafts carried by cast-iron frames bolted to massive concrete foundations. At one end of the kiln a circumferential spur-wheel is attached, beneath which there is a pinion driven through differential worm-gear from a line of shafting extending across the entire series of kilns. This shafting is actuated by two independent steam-engines, each of 350 i.h.p., erected on a bed of concrete resting on piles. In the engine-house for driving the kilns are placed the engine and dynamo sets for lighting the works, the latter engines being of 100 h.p. each. The ends of the kilns nearest the river are slightly elevated, so that a gradual fall exists towards the other parts of the new works. At the same ends, slurry for treatment will be delivered, and here also the steel-plate vertical flues are erected. Towards the lower end of each kiln is an external casing forming an annular chamber for the drying of fuel, and to which we shall refer later; while, at the extreme end, are appliances for stoking, and for the removal of clinker. Next the lower ends of the kilns is a range of buildings, including millhouses for grinding coal, cooling towers for clinker, and millhouses for grinding the clinker. The whole range of rotary kilns will ultimately be enclosed in a building measuring about 320 ft. long by 180 ft. wide. When the slurry is fed into the higher end of the kiln it is distributed over the inner surface by the rotary motion of the apparatus, and gradually works its way down towards the lower end, meeting the hot products of combustion. Water contained in the mixture speedily flies off in the form of vapour, which escapes by the flue, and before the slurry has travelled far it is reduced to the dry state. Then, as higher

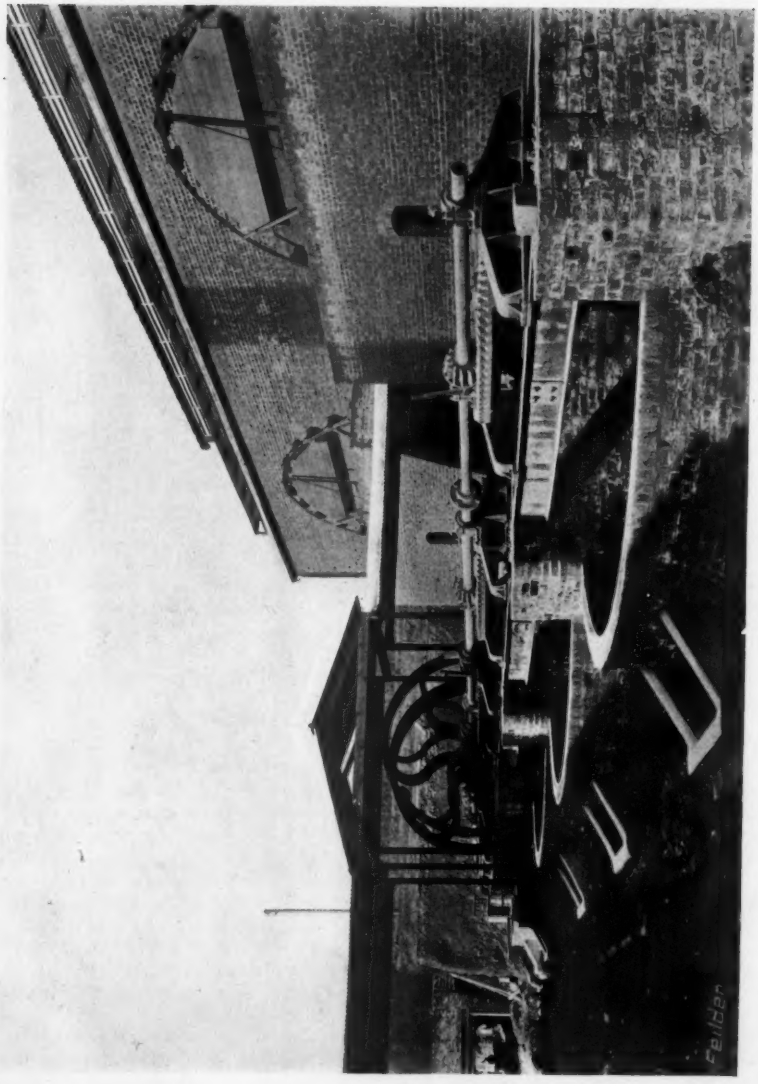


FIG. 7.—NEW COMPOUND MILLS AND WHEEL ELEVATOR.

temperatures are approached, the material approaches vitrefaction, and assumes the form of clinker; but owing to the continuous motion this is prevented from forming into large masses, such as those found in ordinary furnaces, and the clinker drawn from the emptying door is in fragments not much larger than a nut. One end of a conveyor is situated beneath the outlet, and by its aid the material is transported without hand labour to the foot of the cooling towers, where it is automatically loaded into an elevator discharging over the top of the towers. Clinker so delivered settles by gravitation to the bottom of the towers, being met on its way down by streams of cold air blown in at different heights by a blowing engine. From the bottom of the cooling towers, the clinker is carried by another elevator to bunkers situated in the upper part of the millhouse, whence it falls through hoppers to the grinding mills, in which it is converted into finished cement. Each mill-house measures about 300 ft. long × 110 ft. wide, and contains 30 Griffin mills arranged in long rows as seen in Fig. 6. Under each mill is a branch conveyor, delivering into a main conveyor, just as branch drain-pipes discharge into a main drain, and the conveying system continues through the outer walls of the mill-houses to the new cement store, being built near the water-side, and designed to contain 10,000 tons of finished cement. This outline description will enable our readers to realise the salient features of the new system, in which a noteworthy point is the entire absence of manual labour, except, of course, for regulation of the machinery. We will now enquire briefly into the nature of the apparatus designed for the treatment of fuel, and for its delivery to the kilns. In the first instance it should be noted that coal dust, or slack, is the fuel used for firing the kilns, and is mechanically conveyed from the coalheap to the kilns. In order that the use of pulverised coal as a fuel may be entirely satisfactory, it is necessary that the coal should be perfectly dry; and as the slack when delivered from the pits contains from 10 to 12 per cent. of moisture, the first essential is to remove this proportion of water by evaporation. The method adopted at Wickham for attaining this end is to utilise waste heat radiated from the rotary kilns, and the arrangement devised is admirably suited for the purpose. Accordingly, the coal brought to the kilns is loaded into one end of the annular chamber already described as being constructed outside the cylindrical body of each kiln. The inner wall of the coal chamber has a spiral surface, serving to keep the fuel from actual contact with the outer surface of the kiln, and to cause a regular motion of the coal towards the outlet, whence it is carried by a conveyor to a mill in the coal tower. There it is ground to powder, and mechanically conveyed to a hopper placed above the lower end of the kiln. The outlet of the hopper is furnished with a regulating valve, whence a pipe proceeds to the furnace But at a short distance from the point of entry, this pipe is connected by means of a Y-piece with a blast-pipe from a blowing engine fixed below the coal hopper. The result is that fuel is blown into the kiln in a state of division so minute that it is instantly ignited by the intense heat of the furnace. This method of firing constitutes another important advantage to the manufacturer. Up to the present time, the cement industry has been more or less at the mercy of gas companies. Making a liberal allowance for freight, the cost of fuel is reduced by fully one-half by the operation of the new system.

Passing away from the new works, the plot of land is entered where works are soon to be erected for the manufacture of bricks, similar in composition to the internal lining of the rotary kilns, and beyond this site is the engineering department. Here the head of the engineering department is installed in a roomy building providing ample space for general offices, and an admirably lighted drawing office on the first floor. The works include a foundry, where castings are made, up to 3 tons weight; and an evidence of increasing business is to be found in the fact that the foundry is now being enlarged to double the size. Other buildings provide well-lighted and extensive shops for

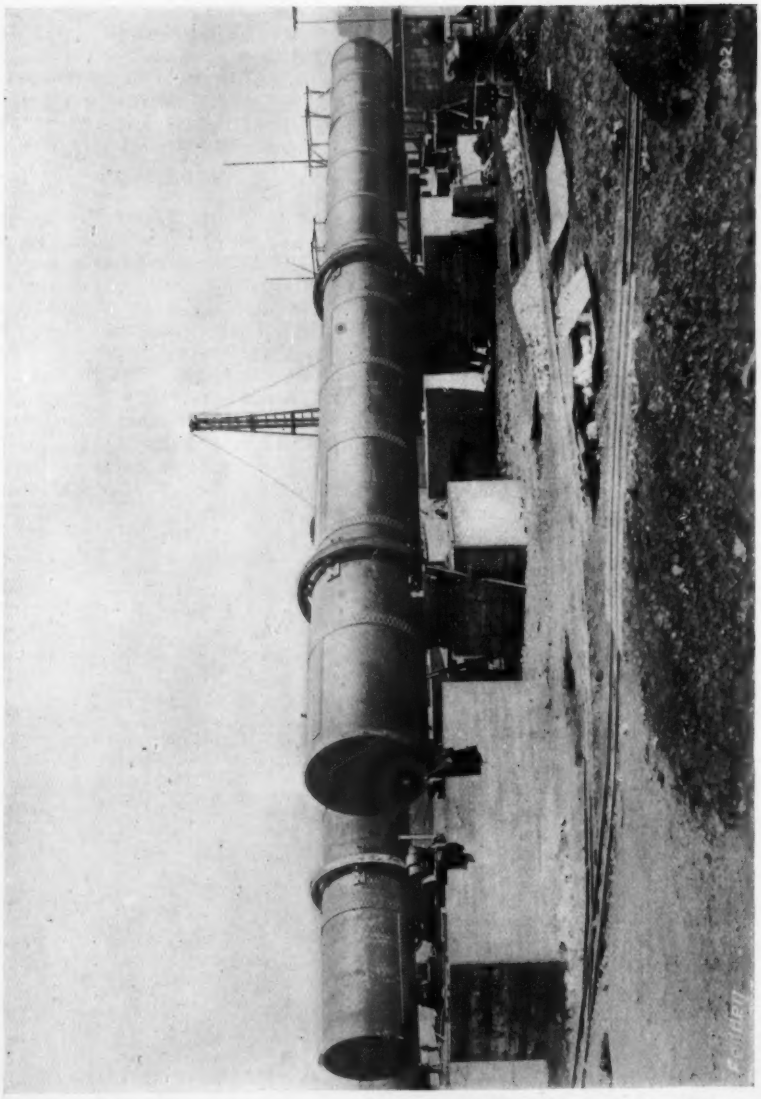


FIG. 8.—NEW ROTARY KILNS IN COURSE OF CONSTRUCTION.

pattern-making, turning and fitting, forging and smith's work, erecting, and boiler-making.

Although a considerable amount of engineering work is executed for outside firms and Government departments in the neighbourhood, the adjoining cement works are sufficient to fully tax the energies of the engineer and his department, especially at the present juncture. In the ordinary way, the whole of the engines and machinery scattered throughout the works must be maintained in perfect working order; and whenever breakdowns occur, or any part of the machinery shows signs of protesting against the unusually heavy work constantly demanded, the necessary repair or renovation must be effected in a minimum space of time. As any stoppage would necessarily involve serious loss, the responsible engineer of the firm has to exercise constant supervision for the detection of any weak points throughout the whole mechanical installation. In addition to the responsibility so entailed, the engineer is busily engaged in the design of the new buildings and machinery, to which we have already alluded in detail. Owing to the marshy nature of the site the whole of the buildings comprised by the new works, and all foundations for kilns and engines, have to be supported by piles driven for a depth of, at least, 30 ft. through the mud, and the most solid form of foundation is necessary to insure stability, because the engines and machinery are of exceptional weight. It may be interesting to mention that the main engines for the mill-houses of the new works were designed and built throughout in the Company's own shops. These engines are of the triple-expansion marine type, each of 750 h.p.; and, although not of showy appearance, they are well-proportioned, and are of the most substantial construction.

Until the extension works are finally completed, and the new system of manufacture has been fully developed, the

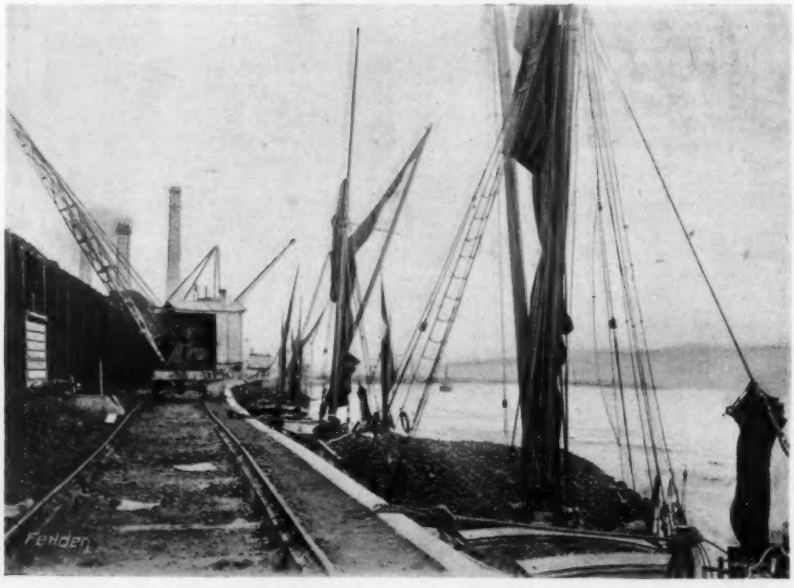


FIG. 9.—VIEW OF THE WHARF FRONTAGE.

heads of the firm will have full scope for the utilisation of surplus energy.

Then, it may occur to them that the old works ought to be reconstructed on the new scheme; and, thereafter, it may be that the desirability of manufacturing improved cement plant for the benefit of an important national industry may come to be considered. We have asked no information on points such as these; but if, as we fully anticipate, the new process should effect a revolution in cement manufacture, we trust that so valuable a means for meeting foreign competition may be made available to all who have so desirable an object in view.

W. M. Thornton

Machinery in the Tea Industry.

By H. J. KERSTING GREEN.

(Continued from page 330.)

❀ ❀ ❀

FIG. 7 is a modern house of A. and J. Main's design, 400 ft. long by 36 ft. wide by 19 ft. high to the eaves, with tiers of galvanised wire netting arranged in racks as shown (Fig. 8). This building would accommodate roughly 8000 lbs. per 100 lineal feet. A liberal, not to say extravagant, allowance of withering space and thin spreading will do much towards surmounting the difficulties arising from bad withering weather; but with a temperature below 80 degs. and humidity 98 to 99 per cent., and the sun obscured for three weeks at a time, a natural wither becomes well nigh impossible. It was well, therefore, that attention was turned towards finding some means for partially, at any rate, overcoming such obstacles.

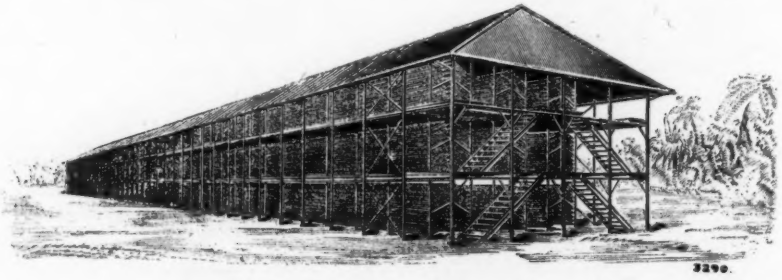


FIG. 7.—MODERN TYPE OF WITHERING HOUSE BY MESSRS. A. AND J. MAIN.

In 1870, Mr. S. C. Davidson, then manager of Burkola, in North Cachar, obtained permission to file a specification in British India for "A process for withering and preparing tea-leaf previous to rolling and finally drying tea," and in 1873, an application was granted to Mr. Ed. F. Skinner, of Silcoorie, in Cachar, to file a specification for withering. From this time onward, the subject of tea-leaf withering continued to engage the minds of many in India and at home; but beyond arranging a floor or second storey in existing tea-houses, or building new ones with a double storey extending over a part or whole of the area, and fixing with racks and trays, thus ultilising the heat ascending from the driers and boiler, the results of which were never considered very satisfactory, nothing further was attempted and carried into effect until Mr. C. A. Turton, then in charge of the Luckwa Tea Co., in Assam, filed his specifications, 148 and 149, of 1886 (British India).

The arrangement was a chamber of convenient size, constructed of wood, at one end of which a charcoal burning furnace was erected, and the heated air forced into the chamber by a fan, the leaf to be withered being placed on trays arranged tier above tier on racks built up on trolleys. These, when filled with trays of leaf, entered the chamber farthest from the fan and were pushed towards it. When ready, the trolley nearest the fan was withdrawn. Opinions

regarding the "Turton Witherer" varied, but on the whole it was stamped with a measure of success.

Among the first, perhaps the first, to make any real attempt to combat the exigencies of climate and effect artificial withering on any scale was the late Mr. E. F. Skinner, who, in 1887 or 1888, installed three 48-in. fans of the well-known Blackman Air Propeller Co.'s manufacture, and by his letter of July 15th, 1888, to that Company, it will be seen how elated he was with his success.

"I am delighted to be able to inform you that my arrangements for withering leaf with the help of your fans have turned out entirely successful. I am now entirely independent of the weather, for in the very worst weather, viz., when the leaf is brought into the factory soaking wet, and the sun is hidden for days, I am able with the greatest ease to wither 100 maunds, = 8,000 lbs. of leaf, in 3½ to 4 hrs. In fine weather I can wither more than double that amount in the same time. In all cases the wither is equal to the best cold and natural wither. You will easily understand that

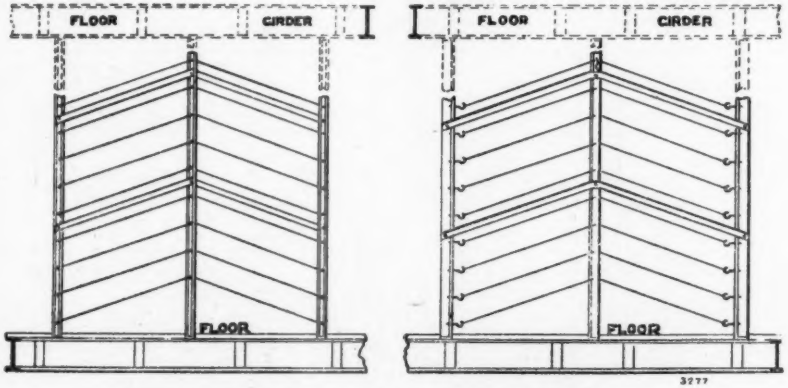


FIG. 8.—GALVANISED WIRE NETTING FOR WITHERING HOUSE.

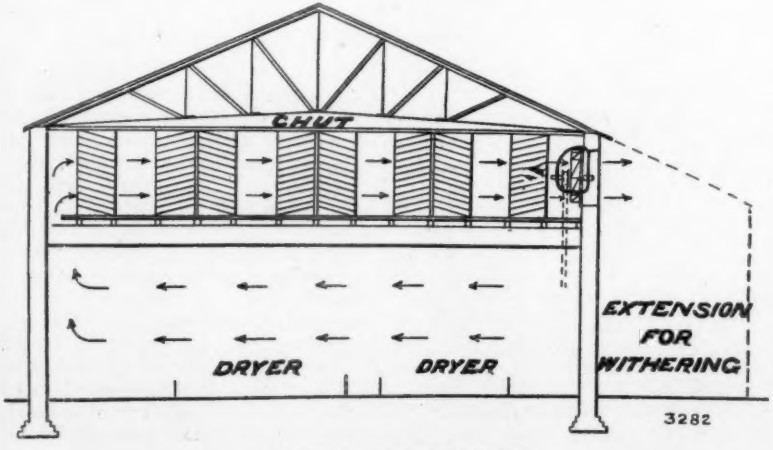


FIG. 9.—CROSS SECTION OF TEA HOUSE.

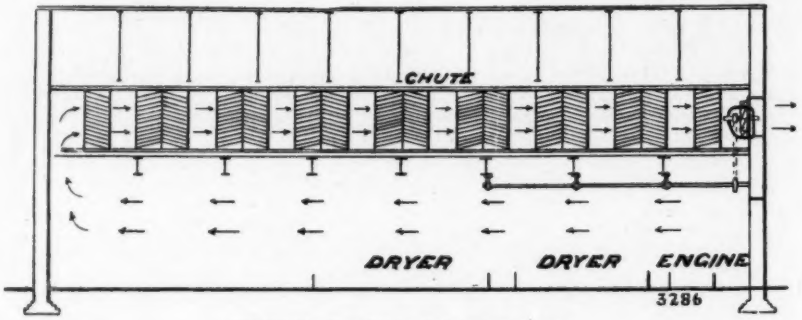


FIG. 10.—LONGITUDINAL SECTION OF TEA HOUSE.

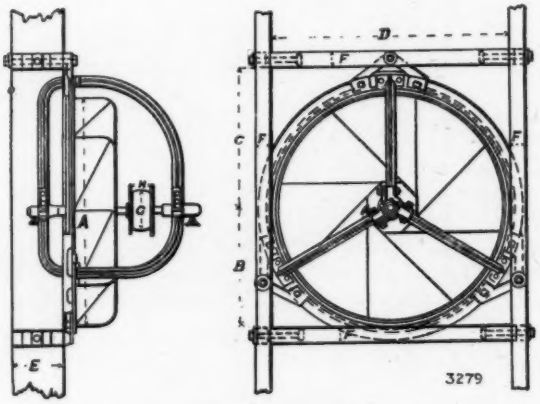


FIG. 11.—TIMBER SEATING FOR 48-IN. FAN.

is the case when I tell you that the leaf gets withered in a temperature of from 86 degs. to 94 degs. My arrangement of your fans is exactly what I described to you in my last letter. The fans are so placed that I am able to use both sides of them. By utilising the heat generated in the factory by the boiler and tea driers, in very hot weather the temperature is reduced by 12 degs. to 14 degs. In the very worst weather the heat so generated is ample for withering purposes. The hot air is withdrawn from the tea-house and made to circulate rapidly over and under the leaf.

"A great number of planters in the district have seen my arrangement of your fans, and all pronounce it a thorough success. I never now wither in the sun, and never use half the withering accommodation I formerly required."

In the complete absence of any desire to detract from the many advantages gained by the adoption of assisted or accelerated withering, the number of planters who expressed themselves in terms of quite so high praise as the late Mr. Ed. Skinner will be found to be extremely limited, and although profoundly thankful for a middle course between two evils when the normal conditions of nature are withheld, they will perhaps never admit that an artificial wither is equal to the natural.

The conditions mentioned by Mr. Skinner are by no means exceptional, and if the figures 20 or 21 are prefixed to the number of days, some idea may be arrived at as to the extent of the dislocation of manufacture, when natural withering has to be depended upon.

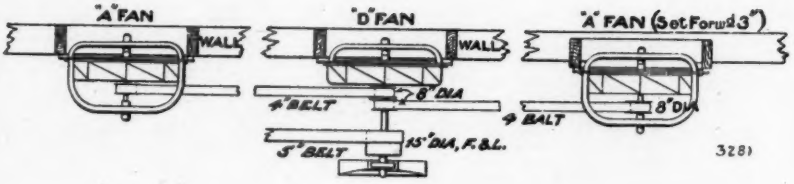


FIG. 12.

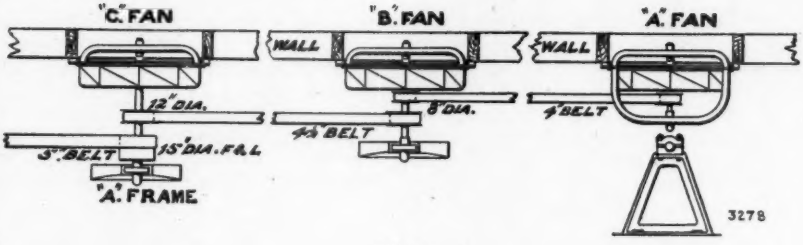


FIG 13.

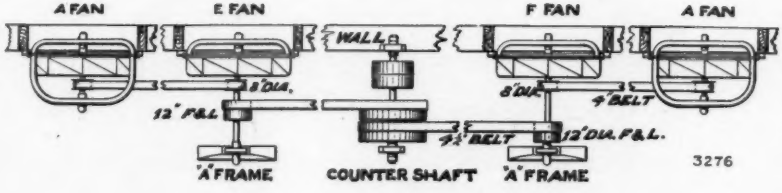


FIG. 14.

SETS OF FANS SHOWING METHODS OF DRIVING.

In arranging the fans, due regard must he paid to the position of the boiler and driers, so as to obtain the best results, also the direction of the shafting, in order that the fans may run the same. Half-twist belts and mule pulleys are to be avoided at home ; in a tea factory they are an abomination.

Fig. 9 illustrates the general arrangement in an ordinary tea-house having a pitch roof, the number of fans being in proportion to the length of the space allotted to withering

Fig. 10 shows a longitudinal section of a house with the fans placed at one end, the arrows in both instances indicating the direction for the heated air in its course through the racks to the fans. In Fig. 10 the extension verandah may be added, and withering performed on the blast side of the fan or fans.

The blast or propelling side of a fan exudes the air in a straight line and is not therefore at any distance from the fan so efficacious as the exhaust or suction. This, coupled with the fact that Turton used dry hot air, may, and no doubt does, account for his witherer failing to score a complete success, because a moist heat, such as would prevail in a tea-house, more nearly approaches the climatic conditions of an ideal natural withering day.

Long before the manufacturing season is in full swing, the rainfall in inches will be well into two figures, and a good

withering day's reading would probably disclose: temperature, 93 to 94 degs., humidity, 96 per cent. Such conditions being available in the factory, why therefore as good a wither should not be produced artificially has not yet found an explanation.

In fixing the fans, the structural arrangements of the house render assistance. Fig. 11 shows the arrangement in front and side elevation of timber seating for an ordinary 48-in. fan, while sets of fans may be arranged in pairs and other combinations, as the accompanying figures serve to illustrate (Figs. 12, 13, and 14).

The fan system of withering was an incentive to the carrying out of diverse and manifold ideas regarding the construction of racks and appliances for containing the leaf during the process, many of them possessing claims to novelty and advantages in the shape of utility and economy.

Fig. 15 is an elevation of a pair of racks of the Bulteel and Green type.

Fig. 16 represents a 40-ft. span house with two chambers, each 16 ft. wide, the whole of the space thus enclosed being filled with trays of leaf.

Fig. 17 is a plan of No. 16 showing the racks and trays in position on the upper part, while the lower portion represents the racks all thrown back against the wall preparatory to refilling with trays of leaf.

A great advantage is obtained in the amount of work done by the fans, as when running in chambers fitted on this principle they are giving results the whole time,

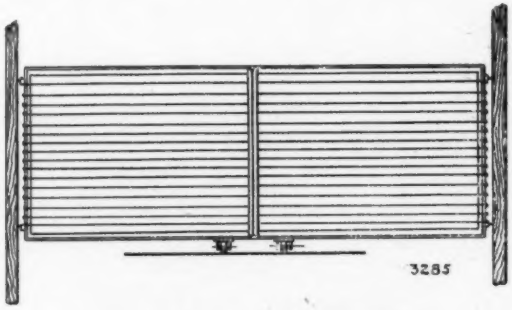


FIG. 15.—BULTEEL AND GREEN TYPE RACKS.

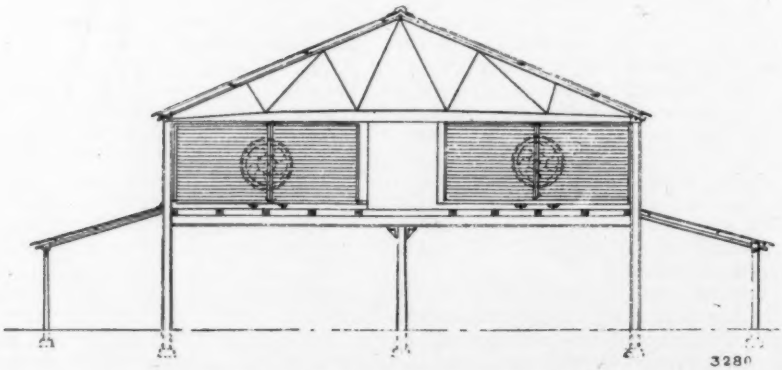


FIG. 16.—SECTION OF 40-FT. SPAN WITHERING HOUSE.

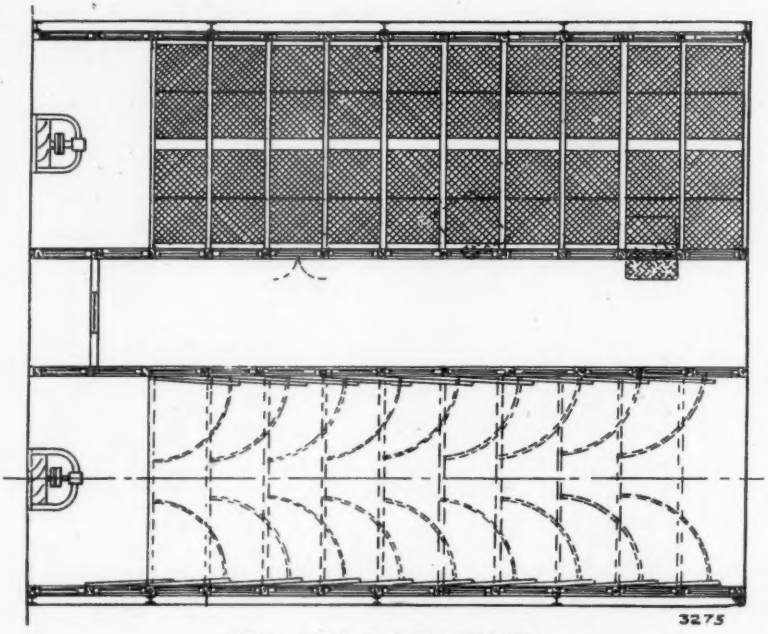


FIG. 17.—PLAN OF 40-FT. WITHERING HOUSE.

and no air is allowed to escape along passages and discharged without having passed over leaf.

In the passage between the chambers, means are arranged for examining the leaf in course of withering, and removal effected if necessary. The results of working were found to be very satisfactory: a chamber 16 ft. wide by 100 ft. long, racks 6 ft. 6 ins. high (allowing 2 lbs. of leaf to every 12 sq. ft. of tray space), 60 maunds (4,800 lbs.) of green leaf, with one 48-in. fan, the leaf was ready in 4½ hrs.

In 1894, Mr. S. C. Davidson was granted letters patent, No. 9965, for improvements in withering arrangements in which moist air was introduced into chambers. Also a machine constructed with a separate engine for driving, so that it might be entirely self contained, and the position in the factory not dependent upon any line of shafting, and might be placed in any convenient out-house.

Mr. Davidson's experiments with this invention attained some considerable success, but perhaps hardly to the hoped-for extent. Satisfied, therefore, up to a certain point, but still left in possession of an element of doubt, Mr. Davidson appears to have traversed the whole ground entirely anew by making experiments under natural, artificial and assisted conditions at varying altitudes. The diagrams produced under all these circumstances would fill many pages; in the meantime it will suffice to say that the conclusion arrived at was that, given a certain percentage of moisture in an atmospheric current under control, temperature might be allowed a range of 60 degs. Fahr., the maximum being 96 degs.; certainly the charts shown the writer by Mr. McGuire, Mr. Davidson's very able assistant (if I have used the word assistant in place of a higher term, the necessary pardon will, I think, be mine), tend to prove this.

The two charts given on pages 428 and 429—the one recording experiments

CAMPDEN HILL ESTATE WITHERING LOFTS.

Elevation, 2000 ft. above mean sea level. Date, 25th June, 1900. Fans used, Four No. 6 Sirocco Centrifugal Wall Fans. Spreading area of lofts, 50,400 sq. ft. Material for Tats, jute hessian. Capacity, 5,040 lbs. green leaf. Condition of leaf on arrival at factory, very wet. Cubical area of lofts, 56,700 cub. ft. Volume of air moved by fans per minute, 25,480 cub. ft. H.P. required for fans, — h.p. Speed of fans, 250 revs. Time required to completely change the air in lofts, 2·2 minutes. Speed of air travelling through lofts, 32·7 feet per minute.

Details of Wither.	Time. P.M. 2	3	4	5	6	7	8	9	10	11	A.M. 12	1	2	3	4	5	
Weight of leaf ...	lbs. 4262																
Temperature, degs.	86	86	83	83	80	80	81	79	78	...	75	...	76	78	79	79	15 hrs.
Hygrometer in loft. % saturation ..	72	68	80	68	80	75	76	80	84	...	94	...	89	84	80	80	
Hours fans run ...	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	
Hours hot air admitted	×																
Weight of withered leaf	..	...	...	...	...	...	...	...	...	...	...	...	...	...	...	lbs. 2244	
% withered down to	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	52%	
Weather	Raining all the time.																

General description of wither: a good moist wither.

OUVAHKELLE ESTATE WITHERING LOFTS.

Elevation, 4,500 ft. above mean sea level Date, 13th and 14th September, 1900. Fans used, Two 35-ins. diam. Sirocco Centrifugal Wall Fans. Spreading area of lofts, 26,472 sq. ft. Material for Tats, jute hessian. Capacity, 2,647 lbs. green leaf. Condition of leaf on arrival at factory, sopping wet. Cubical area of lofts, 33,792 cub. ft. Volume of air moved by fans per minute, 23,430 cub. ft. H.P. required for fans, — h.p. Speed of fans, 212 revs. Time required to completely change the air in lofts, 1·47 minutes. Speed of air travelling through lofts, 44·2 feet per minute.

Details of Wither.	Time. P.M. 12	1	2	3	4	5	6	7	8	9	10	11	A.M. 12	1	2	3	4	5	6	7
Weight of leaf ...	lbs. 948																			
Temperature, degs.	68	69	70	73	72	72	72	72	71	70	70	70	70	70	70	69	69	68	68	69
Hygrometer in loft. % saturation ...	94	94	83	84	89	89	89	79	83	88	83	83	83	88	88	88	88	94	94	93
Hours fans run ...	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Hours hot air admitted																				
Weight of withered leaf	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	..	...	...	lbs. 352
% withered down to	...	...	..	...	...	...	...	...	...	...	..	...	...	...	...	...	...	...	...	56%
Weather	Raining all the time.																			

General description of wither: a good, soft, cold wither, very even.

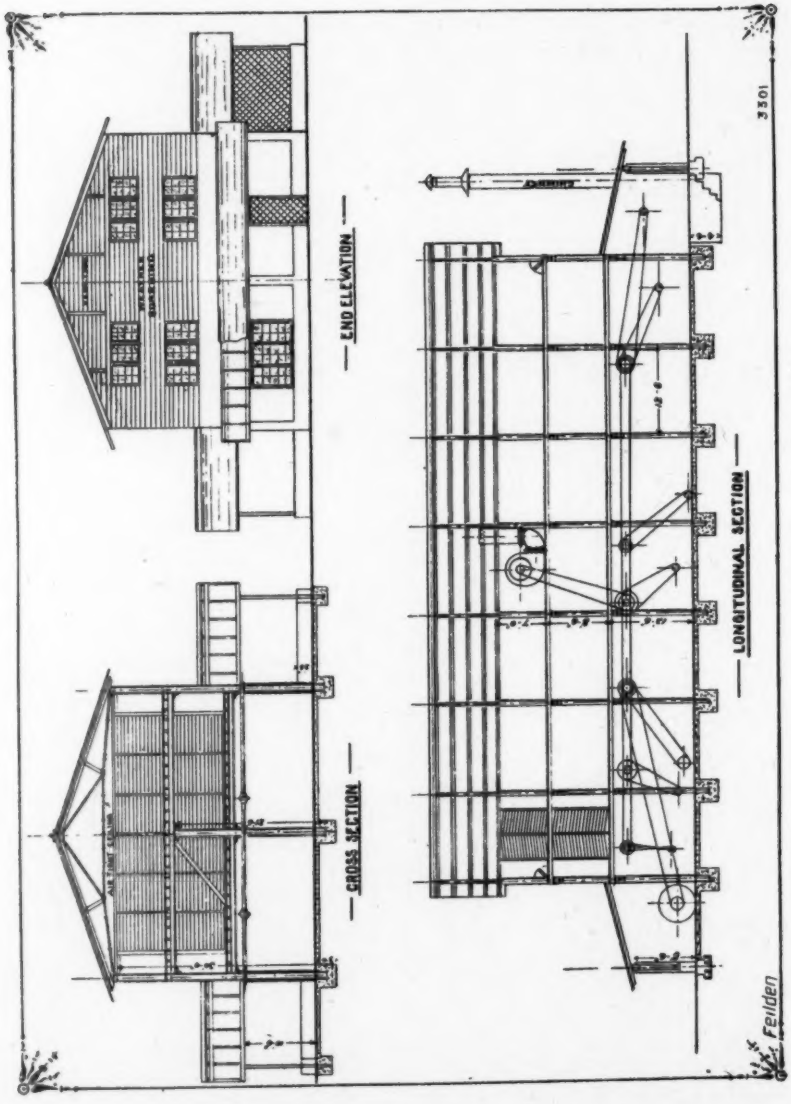


FIG. 18.—GENERAL ARRANGEMENT OF TEMPO FACTORY.

at 2,000 ft. and the other at 4,500 ft. above sea level—were picked out haphazard, and are manifestly illustrative of what can be done under circumstances of the most adverse character.

The cross-section, end elevation, and longitudinal section of the Tempo factory (Fig. 18) tea-house shows the arrangement adopted by Messrs. Davidson and McGuire, a fan of the cased type being placed in the centre of the house on the second storey, drawing and discharging the air heated or otherwise, the regulation of the air admitted being under complete control by means of the trap doors as shown. The "Sirocco" wall fan (Fig. 19), also an invention of Mr. Davidson's, is the latest improvement in machines for suction, applicable for any description of ventilation where arrangements are best suited to the fan being fixed at the end or side of the building. The circumstances attending the installation of fans for withering are of such a varying character as to call for the most careful consideration in each and every separate instance, as manufacturers of fans are all agreed that a very costly arrangement, to all intents and purposes correct, may on the application of tests prove to be utterly worthless. The question of the artificial or assisted wither *versus* the natural will still remain a matter of doubt in the minds of many; but it is not to be supposed for one moment that the subject of tea-leaf withering is to be allowed to remain as it at present

FIG. 19.—DAVIDSON'S "SIROCCO" CENTRIFUGAL WALL FAN.

stands; on the contrary, it continues to engage the most serious attention. The results of the experiments made by Mr. Davidson, of which but an infinitesimal portion is presented in these notes, offer a large measure of convincing proof for the minds of the ultra-sceptical to digest, tending as they do to show that the predictions of twenty years ago bid fair to assume realisation.

(To be continued.)

H. J. Kerslake Green

High-Speed Engines.

By J. H. DALES, A.M.INST.C.E.

(Continued from page 225.)

THE object of this article is to show the effect of compounding on torque. The subject of investigation is a compound engine of the twin-cylinder type, with cranks on opposite centres. The cylinders are respectively 15¼ ins. and 21¼ ins. diameter, and suitable for a 10-in. stroke. The clearances are 6⅔ per cent. all told from the piston to the valve, which is of the piston type in both cases. The clearances are the same proportions in both cylinders. The volumes of the h.p. cylinder, the intermediate receiver, and the l.p. cylinder are respectively 8, 4, and 16; and the system of steam distribution is the nearest possible to the Cornish cycle which can be had in a double-acting engine. Variable expansion in the h.p. cylinder is brought about by an automatic cut-off, controlled by a shaft-governor, and the l.p. cylinder has a fixed cut at half stroke. The h.p. cylinder exhausts into the intermediate receiver, which already contains a pressure which is equal to the h.p. terminal pressure, such intermediate pressure having been compressed by the exhaust action of the h.p. piston after the previous closing of the l.p. valve, which has stopped the flow of the steam to the l.p. cylinder. The h.p. distribution and variable cut-off is performed by a single valve of the piston type driven by a single eccentric, which is mounted on an eccentric boss or bearing, which is fixed on the crank shaft. The eccentric is capable of partial rotation on the fixed boss, such action altering both the angular advance and throw of the eccentric centre. The eccentric is driven and controlled by a connection to the shaft or radial governor.

Figs. 1, 2 and 3, which respectively represent the theoretical action of the steam at ½, ⅜ and ¼ cut-off, explain at a glance the whole of the operations: that the h.p. exhausts into the intermediate receiver, which already contains an equal pressure to the terminal pressure of the h.p. cylinder; that the l.p. distribution valve, opening to the intermediate pressure, lowers the same by the joint increase of volume to the point of l.p. cut-off; that the h.p. piston exhaust is then compressed into the intermediate receiver up to a pressure equal to the terminal pressure of the h.p.; and the h.p. valve then closing to the intermediate, cylinder compression proper takes place in the h.p. to somewhere about the h.p. initial-pressure steam to fill the clearances, and to prevent any loss in admission.

Although the whole of the functions of distribution and automatic cut-off are performed by one valve, with the consequent difficulties of exhaust and compression, it will be seen from an inspection of the diagrams that very correct results are obtained from the arrangement, and which partly accrue from the fact that the h.p. cylinder which is operated on is compounded; that is to say, that so good a result would not be had if the cylinder was working singly.

The base line of the h.p. diagrams, as will be seen, is not straight; and therefore unsuitable for convenient combination with the usual inertia line or curve.

For the purpose of convenient investigation of the combined action of the two cylinders, in the matter of torque, the h.p. diagram is combined with the l.p. diagram by taking half the vertical-pressure lines of the h.p, and plotting them in corresponding proportionate positions over the l.p. diagram, the half-pressures representing the effect as if exerted over the double area l.p. piston. The strong dotted line shows this combination, and is transferred for the three cut-offs to Fig. 4, where both out- and in-strokes are represented, and in which an inertia line for the combined weights of the two piston

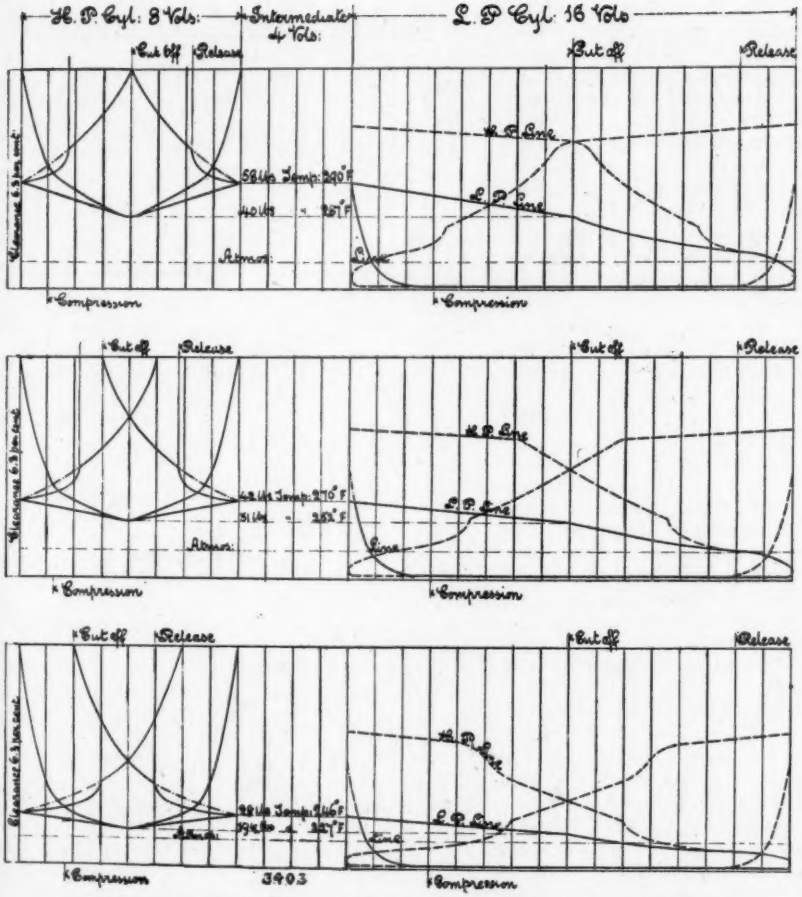


DIAGRAM OF STEAM DISTRIBUTION IN COMPOUND ENGINE.—CYLINDERS, 2 TO 1; INITIAL PRESSURE, 120 LBS. ABSOLUTE; SPEED, 365 REVS. PER MIN.; VERTICAL SCALE, 96 LBS. PER INCH.

lines (1,700 lbs.) for a speed of 368 revolutions per minute, is drawn. The inertia line is, of course, obtained by the same method as stated in article 3. From Fig. 4, a combined torque diagram, Fig. 5 is constructed. This diagram would be a correct conclusion for a pair of tandem cylinders.

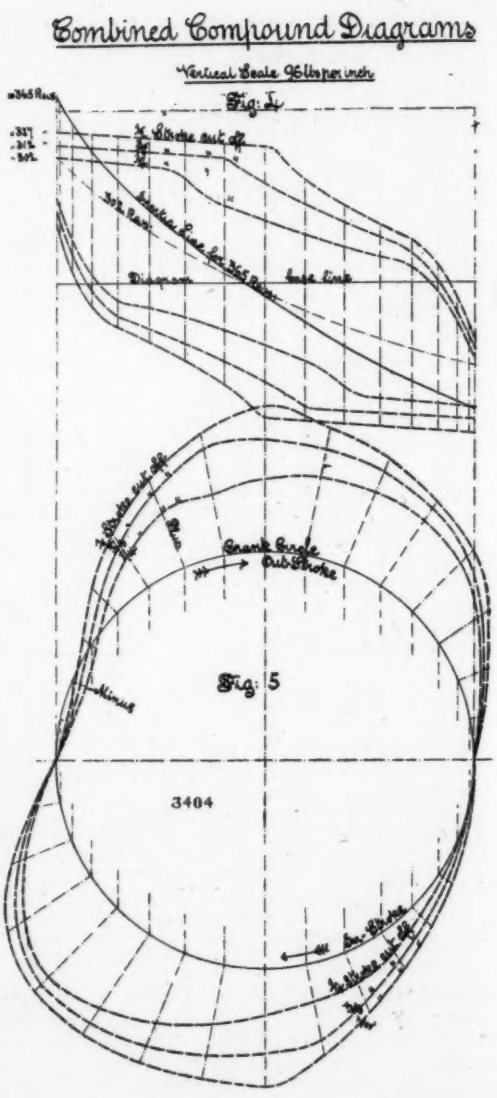
It will be seen that on the out-stroke none of the combined pressures reaches the height of the inertia line, while on the in-stroke they are all on or above that point, by reason of the inertia line on the commencement of the in-stroke being only two-thirds the height of that of the out-stroke. The inertia line is constructed for a 5-crank length connecting-rod which makes the dead point ordinate of the commencement of the out-stroke $\frac{6}{5}$ of the centrifugal force of the piston line, and the same for the in-stroke $\frac{4}{5}$ of such centrifugal force, or as 6 – 4. The three

tangential force lines in Fig. 5 correspond, of course, with the $\frac{1}{2}$, $\frac{3}{8}$, and $\frac{1}{4}$ cut-off diagrams in Fig. 4. Fig. 5 shows that, with the exception of the commencement of the out-stroke, the uniformity of the torque is very fair; but there would be a late knock in the early part of the out-stroke, which would be a bad feature; and it is evident that the speed is too high or the pressure too low for the best results, and that, if all the initial pressures of all the cut-offs are to reach the height of the inertia line on the out-stroke, the pressure would have to be about 180 lbs. per square inch for 368 revolutions per minute.

For the consideration of the individual action of twin-type cylinders which are not tandem pairs, further diagrams of the steam pressures and torque are necessary, and these are shown by Figs. 7, 8, 9 and 10.

Fig. 7 is the h.p. steam diagrams at $\frac{1}{2}$, $\frac{3}{8}$, and $\frac{1}{4}$ cut-off, reduced to a straight-line base for the convenient application of the inertia line. It will be seen that the figures are peculiar: that the earliest cut-off gives the highest initial pressure, and the latest cut-off the lowest. This is, of course, owing to the decreased back-pressure at the early cut-off. The usual deduction is made at the end of each set of figures for compression.

At the beginning of the out-stroke (Fig. 7) all the initial pressures are lower than the inertia line, the late cut-off reaching only about $\frac{5}{9}$ while the early cut-off reaches about $\frac{7}{9}$. The in-stroke shows all the pressures, except the late cut-off above the inertia line, and would be fair for a general result, although in practice the engine friction would increase the defect in the late cut-off. The out-stroke, however, would be distinctly bad, and to take in the late cut-off the speed would have to be dropped to 272 revolutions; or the pressure very largely raised. The torque diagrams of the h.p.



(Fig. 8) on both out- and in-stroke are curious though similar in character; the late cut-off being very deficient in pressure at the early part of the stroke, but predominating at $\frac{1}{2}$-stroke, and later; and both these and earlier conclusions show that with equal power in both strokes no similar torque can be obtained. On the out-stroke of the h.p., considered separately, the steam would not "catch up" the parts until very late, say at about $\frac{1}{8}$-stroke, and a bad knock would be likely to ensue.

Fig. 9 is the steam diagrams of the l.p. cylinder, also shown with an inertia line, the same as Fig. 7. The verticals of the diagrams are doubled in pressure to those of Figs. 5 and 6, but applied to a smaller crank-path to correspond with half volume for the sake of convenient comparison with the h.p. diagram (Fig. 7) and to correspond with the same inertia line to scale per square inch of cylinder area.

In this (Fig. 9) the outstroke diagrams show initial pressures in direct ratio to the cut-offs, and Fig. 10 differs from the h.p. (Fig. 8) in that the torque lines are reversed in order with regard to the minus effect at the commencement of the out-stroke, and are directly according to the cut-off. The lowest pressure ($\frac{1}{4}$ cut-off) corresponds with a speed of 256 revolutions, which is somewhat less than the late cut-off in the h.p. diagram. Altogether the torque results of the l.p. are worse than in the h.p. in spite of the more uniform pressure on the piston of the former cylinder, and that on both the out- and in-strokes.

Quiet running throughout the range shown by the diagrams could not be had over 256 revolutions in a twin-type engine of the proportions dealt with, where single cylinders in each line were used at the pressure shown on the diagrams; but, even if the combined weights were the same, a reference to the combined diagram (Fig. 4) shows that a tandem arrangement of cylinders would admit of the speed being raised to 302 revolutions without any of the combined pressures falling below the highest inertia point on the the out-stroke. But of course it goes without saying that a tandem compound piston-line of much less weight than two separate lines would be practicable; and compared with separate single-cylinder piston-lines (compounded), tandem lines would come in 15 to 20 per cent. lighter. Taking the difference, however, at 15 per cent. less weight, which would be well within the mark, the speed would be raised by working tandem (see Fig. 4) from about 302 revolutions to about 325 revolutions, all other conditions remaining the same. Of course this means raising the usefulness of the engine about 8 per cent., but against this has to be placed, the inconvenience and extra cost of tandem cylinders, as well as the increased difficulties of a valve motion which would provide the approximate Cornish Cycle, which there is little doubt is the best thing to aim at.

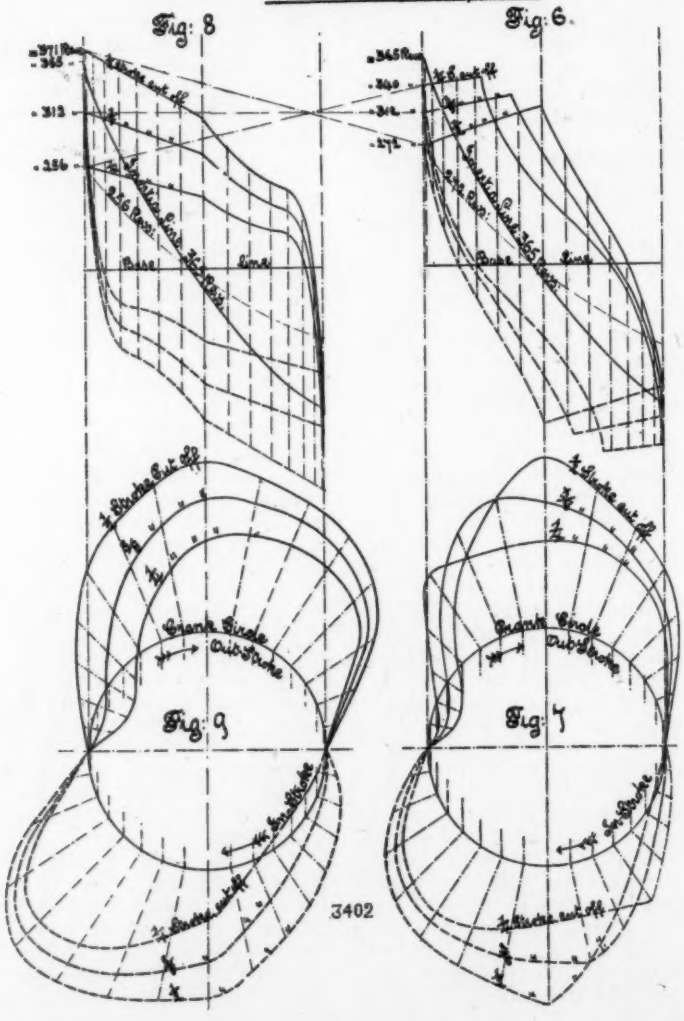
No doubt much more than 15 per cent. could be saved out of the weight of twin single-cylinder compounds by the use of twin tandem cylinders, but of that it is out of the province of this article to enquire.

Of course anything which is done in the way of lowering the weights of piston lines, must in no degree interfere with the margins of strength, but such relief must be obtained by arrangements which are made with a correct appreciation of all the conditions; and it must always be borne in mind that the possibility of accidentally getting the full boiler pressure into any of the cylinders must be taken into account. Several conclusions from the above may be said to be:—that very high speeds entail relatively higher pressures, higher grades of expansion, and a very careful adjustment of combinations of cylinders and weights of piston line, and that twin tandem cylinders have an advantage in the matter of speed over single cylinder compounds.

It will be noted that all the torque diagrams throughout the series show steadiest, or more uniformly variable pressures on the crank-pin in the latter part of the strokes; the irregularities occurring more in the early part of the same; the cause of this being, of course, the constancy of the momentum of the piston lines at any given speed; and it is clear that the most careful attention is

L. P. Diagrams H. P. Diagrams

Vertical Scale 96 lbs per inch



required to the steam effects at the commencement of the strokes, if good, quiet running is desired. Also the diagrams show that excessive pressure on the crank-pin at the end of the strokes may be usefully moderated by compression.

In no case can any considerable uniformity of torque in the early part of the stroke be had from compound engines under variable loads; and they are more difficult to deal with, in this respect, than single engines with variable cut-off, seeing that they largely partake of the nature of throttled engines, in which uniform initial pressure cannot be maintained. Uniform good running can, therefore, in such cases, be only secured by lowering the speed to suit the lowest work diagram which is likely to occur. Marine engines have a great advantage over the stationary type by reason of the constancy of their work, to which all other conditions and proportions can be adjusted, producing results which are quite unattainable in face of the variable work of the ordinary stationary engine, both in the matter of running and economy.

From a commercial point of view, in the matter of price-list horse-power, good quiet running costs more than bad; but, from the point of good turning effect and quality of work produced, the former is really much the cheaper; and the design and "make" of an engine is a matter on which a prospective user should be well advised by an independent technical expert. It is largely due to the neglect of the latter precaution by purchasers that unsatisfactory results are common; and in this particular American methods of operation are better than those holding in this country. From American "rush" or acuteness, probably the former, has sprung the habit in that country of saving money by expending something on information which the average user can scarcely have at his finger-ends. If a man has neither training nor time it is obviously wise to pay for ensuring a certainty.

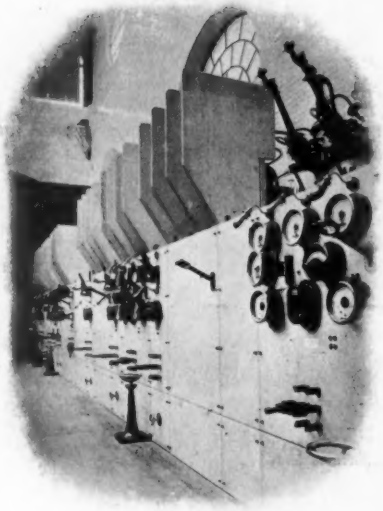
Manufacturers on the average must work to other people's price-lists and sizes, or how can they sell their goods in competition, largely to people whom they never see? It is mainly the consumer who must ask for what he wants; and, if he does that, he is pretty sure to get it "eventually."

(To be continued.)

H. A. Dales

The Connections of Switchgears for Electric Light and Power Purposes.

By W. E. WARRILOW.



THE extremely rapid growth of the electrical industry has caused a one-sided development to take place in the evolution of the methods of generation and distribution, a result which has left its mark upon most of the electricity works at present in operation. The diversity of industries or trades which the commercial application of electricity embraces is in a great measure responsible for this unequal expansion, because at the outset the field was wide and the workers few; so that it was unreasonable to expect that so small a band of men could grasp and undertake the possibilities of the situation. The enormous scope of electrical engineering not only includes such huge industries as those devoted to engine and boiler construction and other large trades, but also such classes of work as porcelain making, slate and marble quarrying, and numerous smaller branches of labour. When this is fully understood it will be more easy to grasp the difficulties which beset the pioneers of electrical work, while greater credit will be found due to those early labours when viewed in the light of modern developments.

The all-fascinating problem has been the generation of electricity, that is, greater attention has been paid to the perfection of the engine and dynamo than to any other portion of the entire system. Strenuous efforts have been made by engineers and electricians alike to so improve their particular portions of the unit that little further could be desired, either in economy, efficiency, or general design. That their labours have met with success a glance into a modern station would show, but what might escape the eye of the average visitor would not pass unobserved by the up-to-date engineer. The feature referred to is the appearance of the switchgear, when compared to the generating plant. Upon a close inspection of the entire apparatus it would be seen that the hand of the engineer had not yet found its way to the switchboard to stamp it with the same brand which marked his engines and dynamos. This marked difference, however, is attributable to the comparative lack of data as to the requirements of a good switchgear, it being a common occurrence for the consulting engineer to either design his own board, or advertise for one on general lines, accepting the lowest of the tenders submitted. In either case the result was far from what could be desired, as in the

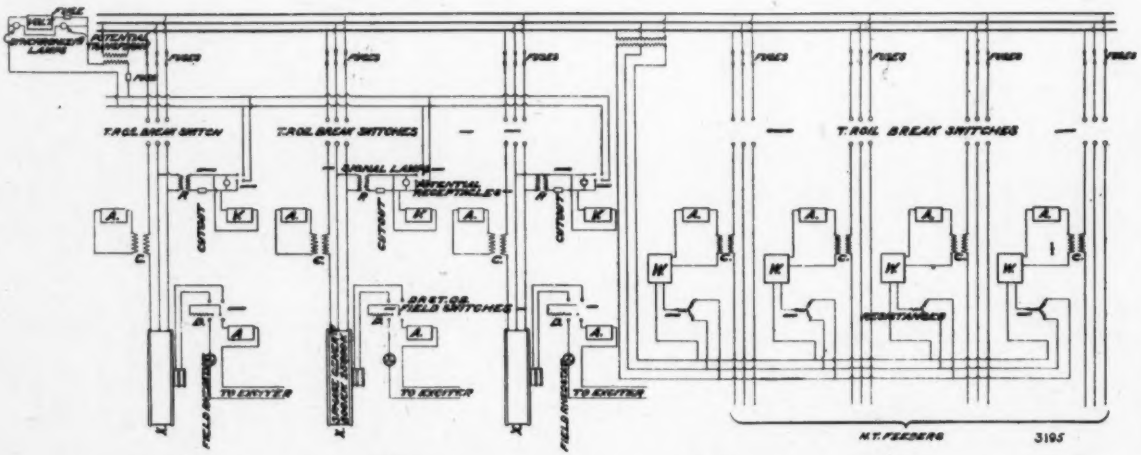
first instance the consultant could not possibly be acquainted with the best methods of construction obtainable (though he would be able to outline the requirements of the case); while in the second case the acceptance of the lowest tender would assuredly result in the exclusion of the best manufacturers, and for this reason. The construction of a switchboard differs materially from that of a generating unit, in that with the latter it is almost impossible to introduce inferior material, but with the former, where much of the apparatus is concealed from view, and under no mechanical strain, every opportunity occurs to scamp the work. The early mistakes in switchgear design, however, soon became apparent, when men were killed in cupboard-like traps containing the connections to the boards. In such instances, little or no blame could be attached to the electrician, who was working in a confined space with high-pressure terminals, having great differences of potential, under his nose. The sense of danger would in no way improve the feelings of the worker, especially when it is understood that the slip of a spanner would probably cost the man his life. Subsequent to such fatalities, the most rigid injunctions were made to switchgear manufacturers that all charged metal should be carefully covered from chances of accidental contact. The death of many good men, and the damage due to fire, on switchboards of faulty design, have, however, been productive of good fruits, and the modern examples of such apparatus are a distinct advance upon pioneer types. A noticeable feature of the gears at present on the market is their division into two classes, differing widely from each other. In the first class is to be found the developments of the early gears, namely, those having all instruments, switches, etc., mounted on the front of slate or marble panels, while the cable connections are made at the back of these panels; and under the second class is a gear of comparatively recent date, having all its fittings, instruments, etc., arranged in slate cells erected on the face of a wall, the various parts of the gear being connected *without the aid of any couplings at the rear whatever.*

The first type has found favour with the majority of engineers by reason of the cost of its production, an item which is comparatively low when compared to a gear of the second class. The extreme differences in construction make this feature more marked, as with the early type the drilling of a few marble or slate slabs and the fixing of them between vertical and horizontal angle irons has been a very easy matter, besides being conducive towards speedy erection. This, combined with the circumstance that the board is of long standing, has placed it in the most important of modern stations.

Gears of the second class, however, are more costly to construct, as well as needing somewhat more care in the arrangement, this in itself adding considerably to the cost of production. Again the gear takes some little time to erect, and it also has to combat what all new arrivals must face —prejudice against innovations.

In the following lines the connections of switchboards generally will receive first attention, subsequent remarks dealing with the arrangement of such requirements as these connections demand in practice.

The simplest form of gear is undoubtedly that adopted on single-phase alternating-current stations, the needs of this case being met by two bus-bars, inner and outer, a switch, fuse and ammeter for each feeder, while the machines required the above plus the exciter gear, consisting of field ammeter, field-breaking switch, and shunt rheostat. The generators supplied the feeders through the bus-bars or bus-cables direct, the additional load being met by paralleling the required alternators on to the bus-bars. The demands of commercial electric supply have, however, not been successfully met by the single-phase system, so that in spite of its simplicity it has had to give place to other methods. Its early rival, the low-pressure direct-current system, has met with considerable favour amongst engineers, and although it bids fair to yield the palm for generating purposes, at any rate, to the three-phase system, it is worthy of con-



A Ammeter.
D Discharge Resistance.
R Potential Transformer.
V Voltmeter.
W Wattmeter.
X Generators.

FIG. 1. DIAGRAM OF THE CONNECTIONS OF A THREE-PHASE HIGH-TENSION BOARD.

sideration in the matter of switchgear, as affording a marked contrast to both single and multiphase working.

The switching apparatus for a direct current station, supplying current for lighting and traction purposes, is rather more complicated than three-phase gear, *i.e.* as far as the connections are concerned.

In addition to the apparatus generally used on a single-phase undertaking, there are needed circuit breakers, acting both on maximum and reverse currents, kicking coils, lightning arresters, and arrangements for the control of currents to balancers, boosters, and a battery of accumulators. In some instances elaborate locking devices are introduced in connection with switches which affect the balancers and boosters, so that mistakes on the part of the attendant are impossible. These precautions have not, however, been generally adopted, as the intelligence of the average switchman can be relied upon to enable him to perform his duties satisfactorily. There can be no doubt that some simple arrangement for the prevention of mistakes would be welcomed, as the closure of a switch or turn of a handle may wreak damage to the extent of thousands of pounds. The majority of attempts at the construction of such a device have not met with any degree of favour to the present time by reason of the undue complications involved, and the gears considered later will not include apparatus of this class.

Switchboards controlling three-phase currents, applied for distribution without the intervention of rotary converters, are nothing more than triple-pole gears, similar to those used on single-phase systems. Where, however, rotary converters are used, the simplicity of the station board must give place to the more complicated arrangements necessary for the starting of the converters, and the direction of the direct currents from them to the traction and lighting circuits.

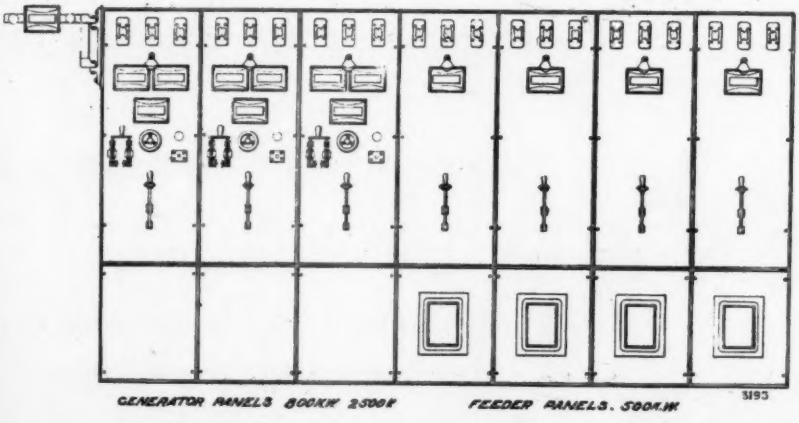


FIG. 2.—SWITCHBOARD SHOWING PRACTICAL APPLICATION OF CONNECTIONS TO A GEAR IN CLASS I.

The employment of higher pressures for generation and transmission has also created a demand for more careful design of the controlling apparatus, both for safely opening the circuit, automatically, and by hand, as well as for the charging and discharging of the transmitting conductors when laid insulated in the ground. With these extra high-pressure gears it is more than ever essential that perfect safety in operation be attained as well as complete immunity from danger, should

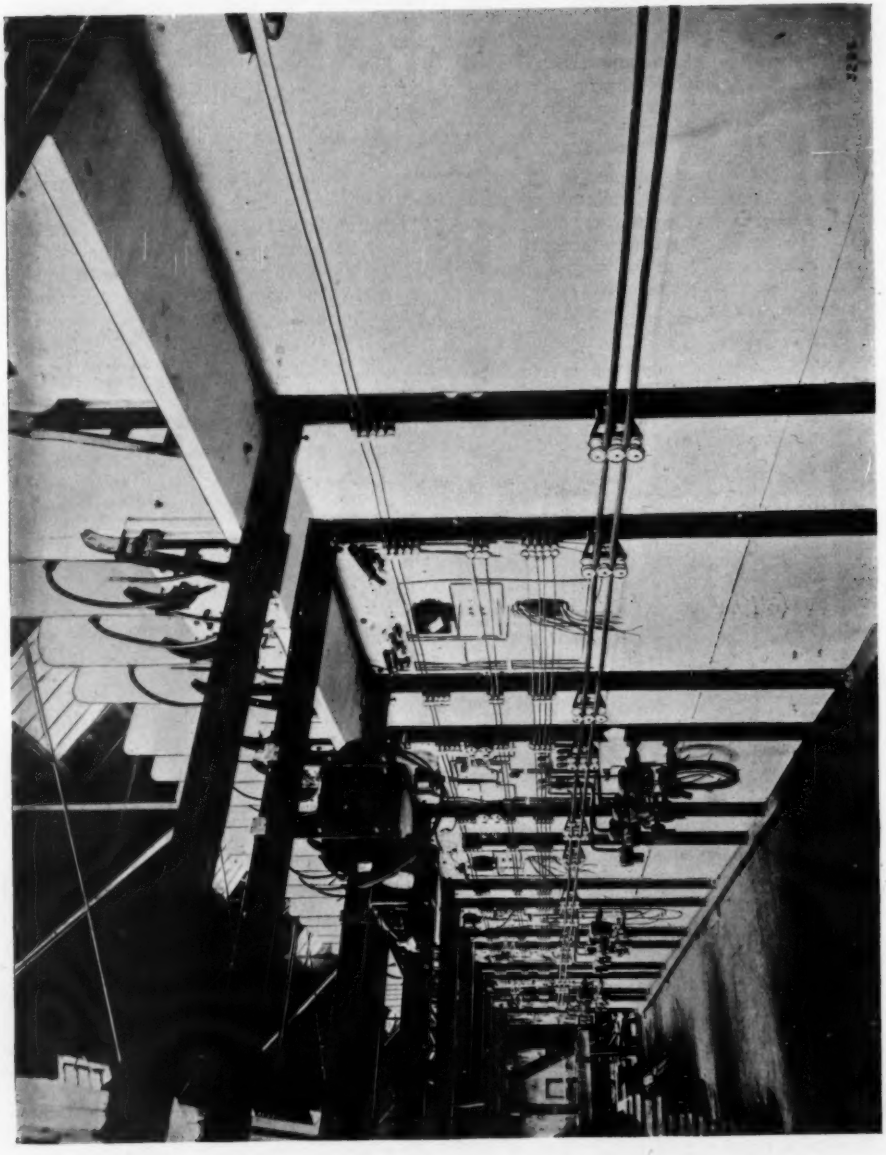


FIG. 3.—PHOTOGRAPHIC VIEW OF BACK CONNECTIONS OF BOARD IN CLASS

work have to be carried on in the neighbourhood of charged metal.

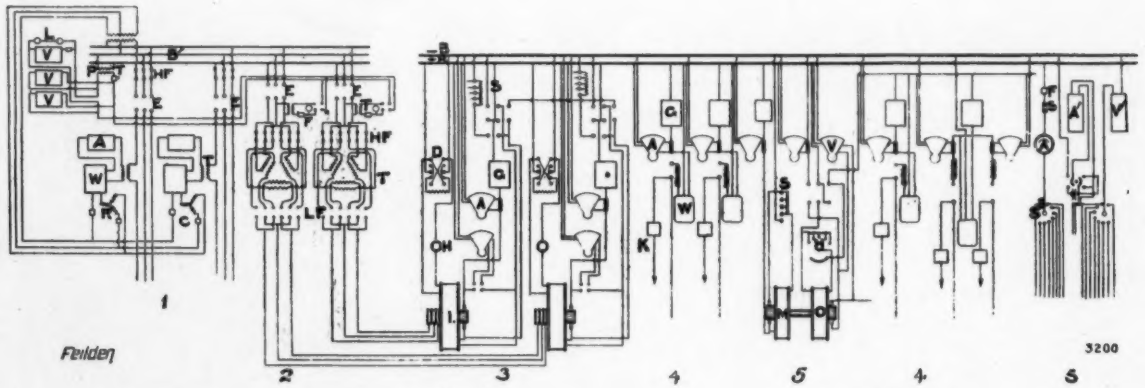
In considering the fulfilment of the necessary conditions demanded by the connections of a switch-gear, the embodiment of these conditions in the two classes above referred to will be detailed, the boards under classes one receiving attention first. In the short space of an article of this description, it would be impossible to enter fully into particulars of all classes of gears, as there are so many types which claim equal attention; it will, however, be sufficient for the purpose in view, to take a few examples from the number presented for choice.

In Fig. 1 will be seen a diagram of the connections of a three-phase high-tension board, controlling currents supplied from three generators to four feeders. Through ammeter switch and fuse the three-phase currents pass to three bus-bars, to which the feeders are connected through fuse, switch and wattmeter, while the additional machines can be paralleled on the same bus-bars, should occasion demand it. Arrangements for controlling the exciter currents are also necessary, and these take the shape of ammeter, rheostat and field-breaking switch. The latter short circuits the alternator field on a non-inductive resistance after breaking the exciter circuit. A signal lamp to indicate when a machine is run up to volts enables the attendant to make sure that he is switching in the correct generator, a precaution which is of considerable moment, as a standing machine can easily be put in circuit by mistake. A double pole plug is provided for use in the potential receptacle to place the synchroniser in circuit with the incoming machine, it being necessary in this case, however, to have but one plug in use on the board, as the insertion of two will bring about a short circuit between the generators.

The practical application of these connections to a gear in Class 1, is illustrated by Fig. 2. The frame-work comprises steel angle-irons firmly bolted together, stayed a given distance from the face of a wall to allow a clear space at the back, and arranged to receive marble panels in such a manner that the supports do not take up the connection area at the rear of the panel. All fittings are so constructed that the working portion is presented to the front of the slate, while provision is to be made at the rear for the couplings to the bus-bars to be easily fitted. The bus-bars themselves are carried in insulators on brackets bolted to the iron work, special precautions being taken to prevent breakdown. The failure of a bus-bar is analogous to the bursting of a main steam-pipe, in that both act as bridges between two important sections of the supply system. A steam-pipe may however be duplicated, but no such provision is possible with switch-gears, of this particular type at any rate. Referring to the figure, the generating panels occupy the left hand of the gear and the feeder panels the right, an arrangement which permits of the addition to either section without in any way disturbing the rest of the gear. The fuses which break in air are mounted at the top of each panel, below them are the voltmeter and ammeter in the alternating-current circuit, and directly below these is the field ammeter. The centre of the panels is taken up by the field-breaking switch, the rheostat hand-wheel, the pilot lamp and the potential receptacle. At the bottom of the slab is the switch handle for opening the high-tension circuit, the switches themselves being arranged at the rear of the board and carefully guarded from contact of any sort.

The feeder panels differ only from the generators, in that they have no exciter gear and are provided with wattmeters for measuring their respective outputs. These are mounted below the main slabs on panels of small dimensions, and similar panels, though left blank, are mounted beneath the generators to preserve the symmetry of the gear. The transformers for the wattmeter shunts and the synchronisers are mounted at the rear of the board in the most convenient positions.

The left-hand top corner of the board is occupied by the synchroniser, voltmeter and lamps, mounted on a swing bracket so that each can be easily seen down the length of the board, and also pushed back out of the way when not in



A	Ammeters.	*F*	Fuse.	*S*	Starting Switch.
A'	Recording Ammeter.	*H F*	High-Tension Fuses.	*G*	Circuit Breaker.
B	(− & +) Direct-Current Bus-Bars.	*L F*	Low-Tension Fuses.	*H*	Rheostat.
B'	High-Tension Bus-Bars.	*E*	T.P. Oil Break Switches.	*I*	Rotary Converter, 500 k.w.
L	Synchronizing Lamps.	*W*	Wattmeter.	*K*	Lightning Arrester.
V	Voltmeters.	*R*	Resistance.	*S*[8]	8-point Switch.
V''	Recording Voltmeter.	*C*	Cut-out.	*M*	Motor.
T	Transformers.	*D*	D.P. D.T. Field Switch.	*O*	Booster.
P T	Potential Transformers.				
1	Incoming H.-T. Feeders.	3	Rotary Converter Panels.	5	Motor Booster Panel.
2	Transformer Panels.	4	Feeder Panels.	6	B.O.T. Panel.

FIG. 4.—DIAGRAM OF THE CONNECTIONS FOR RUNNING THREE-PHASE ROTARY CONVERTERS FROM HIGH-PRESSURE FEEDERS, TO SUPPLY DIRECT-CURRENT FEEDERS.

use. The connections between the various fittings of the board are made either by means of flexible conductors or by copper links bent to the required shape. It is a difficult matter to do this part of the work with any degree of neatness, as the particular fittings cannot be always arranged in the best positions, and a large number of straggling leads are always hanging about. An idea of the rear of a board of this type (though not of the board under consideration) can be gathered from Fig. 3 which illustrates the back connections of a board (in the shops), the main cables not yet being in position. At times, when connecting these cables to the board, there are great difficulties experienced in making a neat arrangement, the confined space to work in and the more or less straggling nature of the fittings in the panels being the chief causes of this.

Fig. 4 is a diagram of the connections necessary for the running of three-phase rotary converters from high-pressure feeders, to supply a direct-current network for lighting and traction. The essential conditions of the arrangement are as follows :—the incoming feeders are carefully switched and fused, and their out-put measured on a wattmeter, while an ammeter in circuit indicates the current passing. Through bus-bars the feeders supply transformers for lowering the pressure to the rotaries, and the primary circuit of these converters is provided with switch and fuse on each phase, while fuses only are inserted in the secondary circuit, which leads direct to the three-phase side of the rotary itself. The direct-current side of this latter includes the switching arrangements for starting up, current passing from the direct-current bus-bars through an adjustment resistance, circuit breaker and ammeter on one pole and on the other through a throw-over switch. When the converter has reached synchronism it is thrown in circuit with the high-tension transformer and feeder, and the starting

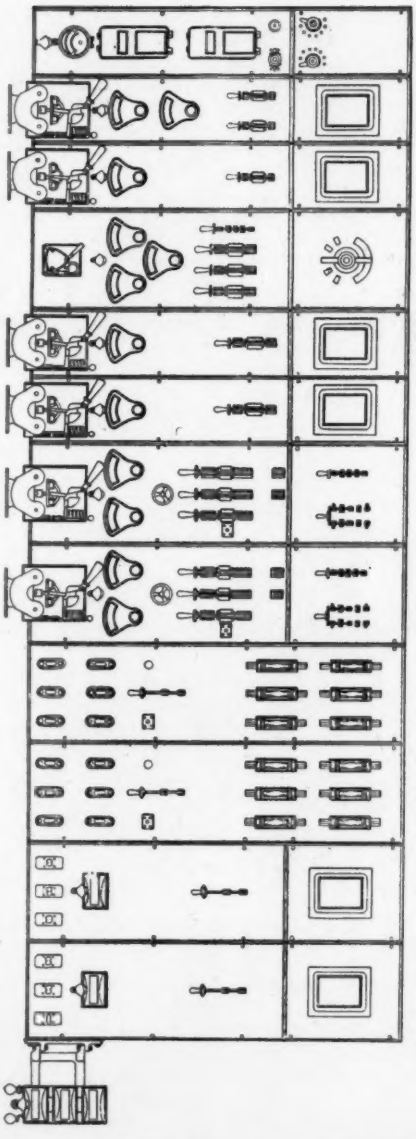


FIG. 5.—DIAGRAM OF THE PRACTICAL APPLICATION OF THE CONNECTIONS SHOWN IN FIG. 4.

switch on the direct-current side is changed over to the bus-bars, cutting out the resistance.

The machine then runs as a compound-wound continuous-current dynamo, and is suitable for both lighting and traction load combined. When run in parallel with another rotary, a switch is provided to bring both series windings into conjunction through an equaliser bar. The field-switch is of necessity arranged to reverse the connections, should the rotary field "build up" in the wrong direction, a not unlikely occurrence. The switch, however, is provided with discharge contacts for both changes, so that there need be no fear of their windings becoming "pierced" when breaking so highly inductive a circuit.

A rheostat in series with the field-connections completes the necessities for this portion of the gear. The feeder panels, with circuit breaker, ammeter, wattmeter, switch and lightning-arrester are also required, the final items taking the form of a motor booster and Board of Trade panels. The former comprises a direct-current motor with an ammeter and starting switch in its circuit. The booster is a dynamo whose armature is placed in series with the negative feeder, which is generally connected to the rails. The arrangement is used to draw currents which may tend to stray to earth from the rails (through the negative feeder).

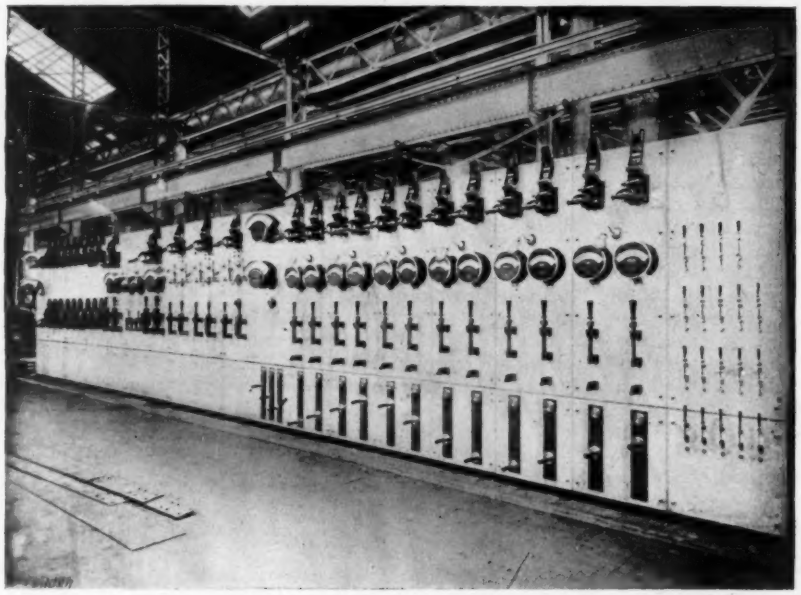


FIG. 6.—FRONT VIEW OF DIRECT-CURRENT BOARD OF A ROTARY CONVERTER SUB-STATION.

The Board of Trade panel provides for tests which are enforced by that body, comprising the rail drop in volts, earth leakage from rails to negative main at station, and trolley wire leakage to earth.

The practical application of these connections is illustrated by Fig. 5, which is a front view of a sub-station board. On the left are the high-tension feeder panels, equipped with oil break switches, fuses, ammeter and wattmeter. Adjoining these

are the transformer panels which carry the primary and secondary fuses and high-pressure switches. To the right of these are the rotary converter panels, and they are fitted as follows :—The upper panel contains the circuit-breaker at the top surmounting the ammeter and voltmeter, below which is the rheostat handle. The bottom of the slab is occupied by the starting switches, which throw over also when the rotary has attained its speed. The smaller and lower panel holds the field switch for both breaking and reversing the field connections. Feeder panels adjoin the converters and they are fitted with circuit breaker ammeter, switch and wattmeter on the front and lightning-arrester and kicking coil at the back. "Sandwiched" between the feeders is the motor booster panel, carrying ammeter and starting switch in the motor circuit, and ammeter, voltmeter, switches, and rheostat in the booster circuit. The extreme right of the board is occupied by the Board of Trade panel, mounted upon which will be seen the recording ammeter and voltmeter, and multiple contact switches. A swing bracket at the left-hand of the gear carries the lamps and voltmeters necessary for synchronising. As with the previous arrangement for a central station, the board is made up of marble slabs mounted in a steel framework, the front of the slabs carrying the fittings, while the rear is occupied by bus-bars, resistance frames and cable connections. The photographs which make up Figs. 6 and 7, illustrate a direct-current board of a rotary converter sub-station, both front and back being depicted. It will be gathered from these, that although a "showy" front can be given to such a board, the connections at the rear quite take away whatever may be pleasing to the eye at the front.

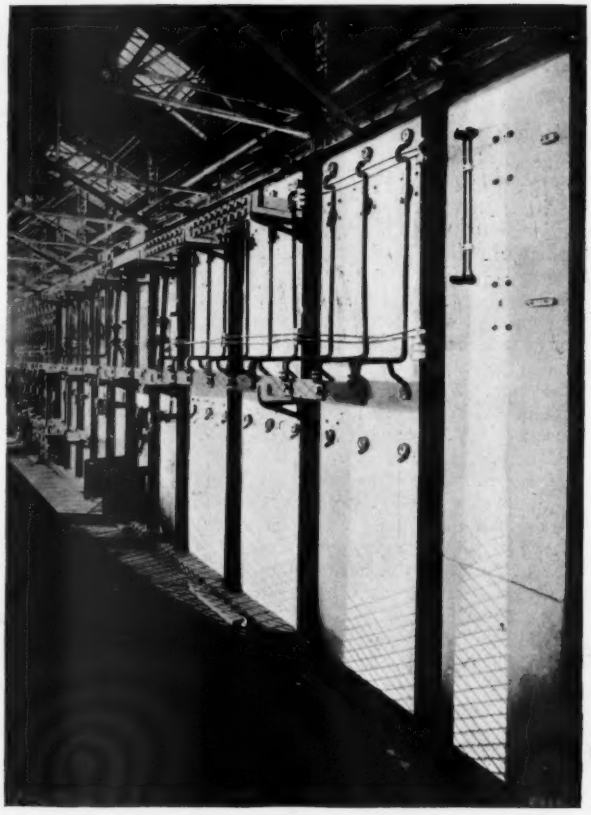


FIG. 7.—BACK VIEW OF A DIRECT-CURRENT ROTARY CONVERTER SUB-STATION BOARD.

(To le concluded.)

W. W. Warnlow

The Kitson Light.

In our issue of October last some description was given of the system of incandescent oil-lighting introduced by the Kitson Company, and our readers will probably be interested in the further details now presented. The principle embodied in the new light was accidentally discovered about sixteen years ago by Mr. Kitson, when resident in Philadelphia. During the course of some experiments conducted with the object of enriching coal gas with oil vapour, Mr. Kitson found that an exceptionally brilliant illumination was obtained by applying the flame of a bunsen oil-burner to platinum gauze. Turning aside from his original quest, he devised an experimental lamp for the purpose of examining the new form of light. In this apparatus, of which a sketch is given in Fig. 1, the oil was supplied to a vaporising chamber, initially heated by outside means; and, when in operation, by the heat of the burner itself. Although the incandescence of platinum produced a sufficiently brilliant light, the metal speedily became spongy, and its light-giving power rapidly deteriorated. At that time the Welsbach mantle was in its infancy, and was too fragile to be used on a burner of the type required. Mr. Kitson was, therefore, obliged to abandon any idea of placing his new lamp on the market, and it was not until six years ago that the mantle industry became sufficiently developed to enable him to take steps for its manufacture. During the years 1896–7 application was made to the United States Patent Office in respect of a claim covering the entire art of incandescent lighting by petroleum under pressure. Other applicants had entered claims of limited character, and naturally subordinate to the broader claim of Mr. Kitson. Testimony was received, and the patent records of the United States and other countries were searched with the view of determining the question, which was finally decided in favour of Mr. Kitson by the Commissioner of Patents. The system is now patented throughout the world, being protected by several hundreds of patents, of which no less than eighty-five have been issued in the United States. Another inquiry was instituted in 1899, by the German Patent Office, and determined in favour of the inventor. So far, therefore, the position of the company appears to be reasonably assured.

In 1896, the Kitson light was exhibited in a practical form in New York and in Philadelphia, where it created considerable interest. In the following year the Kitson Incandescent Lighting Company was incorporated with a capital of 3,000,000 dols., and in 1898 the United Gas Improvement Company purchased the patent rights for the United States and Canada, making them the basis for another corporation, with a capital of 12,000,000 dols. The turn of this country then came, and six months ago the Kitson Lighting Company was formed to exploit the British patents, while yet another company was incorporated on the Continent.

The Kitson lighting-plant consists essentially of three parts:—(1) the reservoir or tank in which the oil is kept under pressure; (2) the conducting tube; and (3) the lamp or burner. The first of these is a pressed or drawn steel cylinder, illustrated in Fig. 2, made in two parts, the upper portion being pressed out of a single sheet of steel and the lower portion turned in and brazed. The reservoirs are made in sizes varying from five to fifty gallons capacity, being provided in every case with a gauge for indicating the oil level; a filter (2) having a tube that extends to within 1 inch from the bottom, and through which oil is forced into the conducting tube, with a regulating valve (4); an air-pump, (5) for establishing an

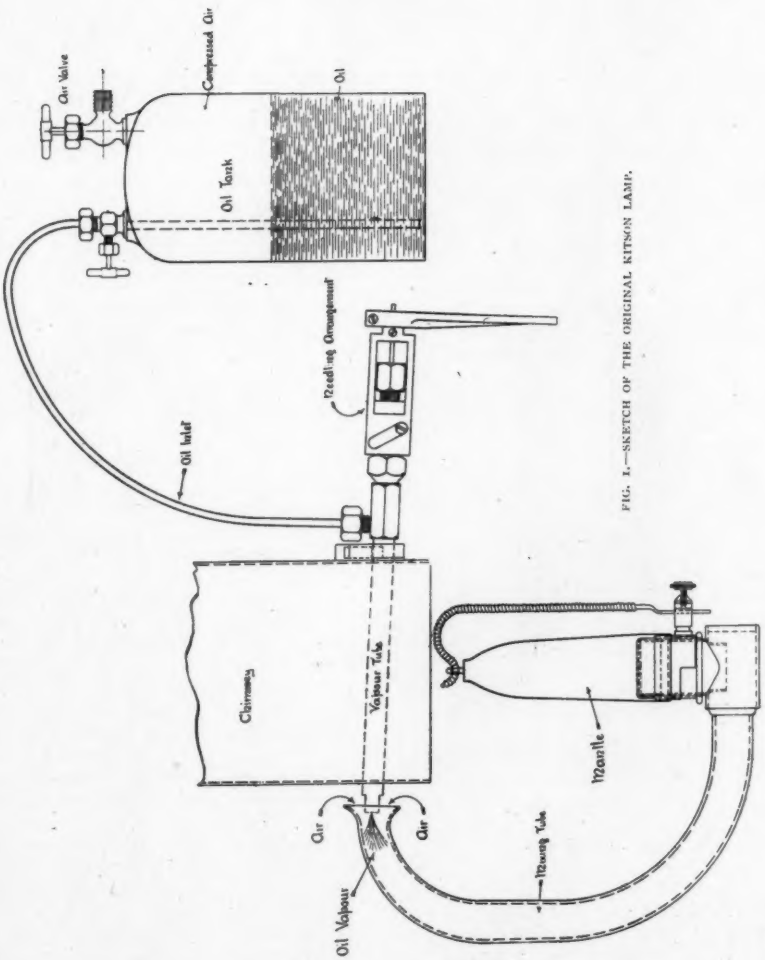


FIG. 1.—SKETCH OF THE ORIGINAL KITSON LAMP.

air-pressure of 50 lbs. per square inch above the contained oil, and a pressure gauge (3), showing the air-pressure in the reservoir.

The conducting tube is formed of bronze, sufficiently ductile in nature to enable it to be bent at right angles without closing the orifice. The tubes are manufactured in four sizes, varying from $\frac{1}{32}$-in. to $\frac{1}{4}$-in. internal diameter; and as the amount of oil required per lamp is very small, it is said that a tube of $\frac{1}{4}$-in. bore is adequate for the supply of twenty-five 1,000 candle-power lamps. The supply of oil from the reservoir to the lamp is controlled by a small valve, and the tube can be run to any required distance from the reservoir in wood casing, similar to that employed for electric-light wires. The lamps are of various forms, according to the purposes for which they may be wanted; but, to make our general description complete, it may be explained that a typical lamp, as represented by Fig. 3, includes a vaporising tube placed above the burners, so that oil fed in at one end shall be converted into vapour by the heat of the lamp. The other end of the tube is in communication with a mixing tube leading to the burners, and fitted with an adjustable air inlet to ensure the proper admixture of air for the bunsen flame.

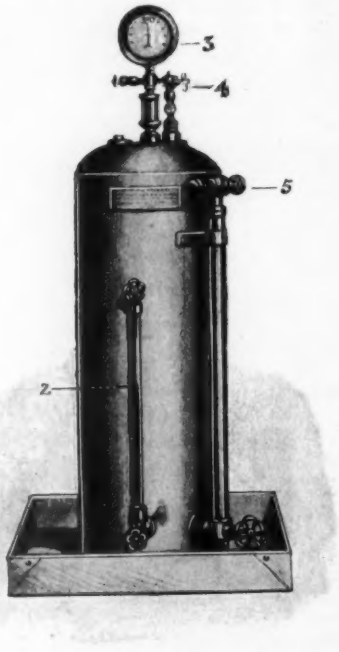


FIG. 2.—RESERVOIR.

One of the greatest difficulties originally confronting the inventor was that of inducing the lamp to light when wanted. It is evident that before a light can be produced, the vapour tube must be heated up to the temperature when the oil becomes vaporised, otherwise, the oil would flow into, fill, and overflow from the mixing tube. To accomplish the desired result several methods have been tried. One was to fix under the vapour tube a small cup wherein methylated spirit was burned to provide the requisite heat. Another plan was to employ ordinary gas by means of a bunsen burner for the same purpose. Again, the aid of a plumber's torch was invoked, and a further method tried by Mr. Kitson was to furnish the vapour tube with an internal platinum wire, which, being electrically heated, caused instant vaporisation. Some of these devices seem to be unsatisfactory and others inappropriate. Methylated spirit and the plumber's torch are not to be recommended, and a system of lighting that is intended to out-rival gas and electricity ought not to be dependent on those sources of illumination for starting power. Probably the inventor has realised this serious objection, for his last method of starting the lamp is to heat the vaporising tube by gas derived from petroleum ether contained in a small carburettor placed near the reservoir. When the flame is properly applied, the latter method is said to render the tube of such temperature that the oil may be turned on after twenty seconds have elapsed.

Two forms of lamp are made for domestic use, one to stand on a table, and the other to be suspended from

a ceiling or other support as Fig. 4. In the table lamp the burner is screwed on top of the reservoir, the conducting tube being inside the reservoir. Suspended lamps are usually served by pipes carried from one or more reservoirs and a type largely used for the illumination of shops, factories and halls, has two mantles placed side by side over corresponding burners. A serviceable lamp for contractor's use is also made, and comprises a reservoir standing on the ground and steadied by three extended legs, the lamp proper being fixed on the top of a strong post attached to the upper part of the reservoir. Street lamps are of varied patterns, the ordinary kind having a post with a chamber in the base, Fig. 5, wherein the reservoir is situated, the burners being supplied with oil by a conducting tube carried through the pillar. For lighthouse purposes certain modifications of the lamp have been found necessary, as the upper part of the lamp prevented a large proportion of the rays from reaching the reflecting lenses. A recent trial of the light has been made at the Lowestoft high lighthouse, under the supervision of Mr. T. Matthews, engineer to the Trinity House Board; and it is believed that the suggestions put forward by that gentleman will have the effect of increasing the efficiency of the lamp for lighthouse purposes. The Kitson light has a uniform steadiness and the power of penetrating fog for considerable distances. In these respects it is certainly superior to the electric light, as it is in brilliancy to ordinary petroleum lamps.

The physical characteristics of the light are worthy of remark. It more closely resembles natural light than any other artificial illuminant. Its diffusive quality is good, so that there is an absence of very black, or well-defined shade. Although brilliant, it is not trying to the eyesight, and can therefore be used in clear glass without injurious effect. With regard to the cost of maintenance, the recent test made by the Lighting Committee of the Aberdeen City Council shows that 1,000 candle-power per hour can be produced at the cost of one-penny and eight-hundredths, including labour, maintenance charges, oil, mantles, and globes. This price could be further reduced, as the Kitson Company is willing to contract for the supply of oil and mantles at prices that would bring down the cost of a 1,000 candle-power per hour to four-fifths of a penny. When figures are put forward with the object of demonstrating the comparative cost of different systems of lighting, it is absolutely necessary to know whether the unit charges in the particular district selected are normal or abnormal. Otherwise misleading deductions may be drawn. In some places gas and electricity may be dear, and in others cheap, whereas

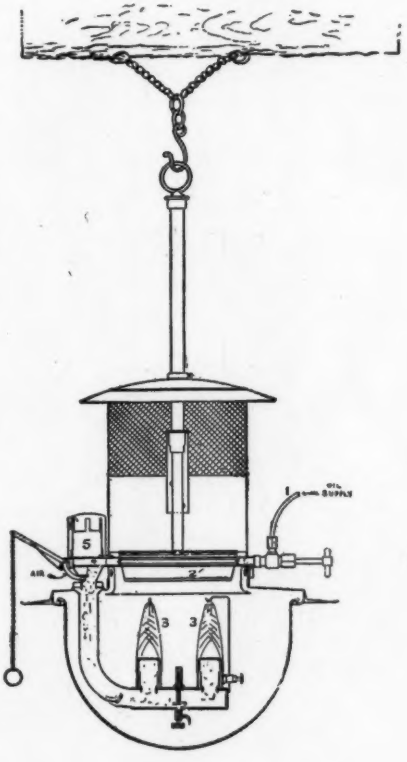


FIG. 3.—SECTION OF KITSON LAMP.

the price of oil is practically uniform in all parts of the country. Consequently, the Kitson may show to great advantage in one town, and to very little, if any, in another. As a general rule, however, the use of oil in any form usually results in saving, and the adoption of the incan-

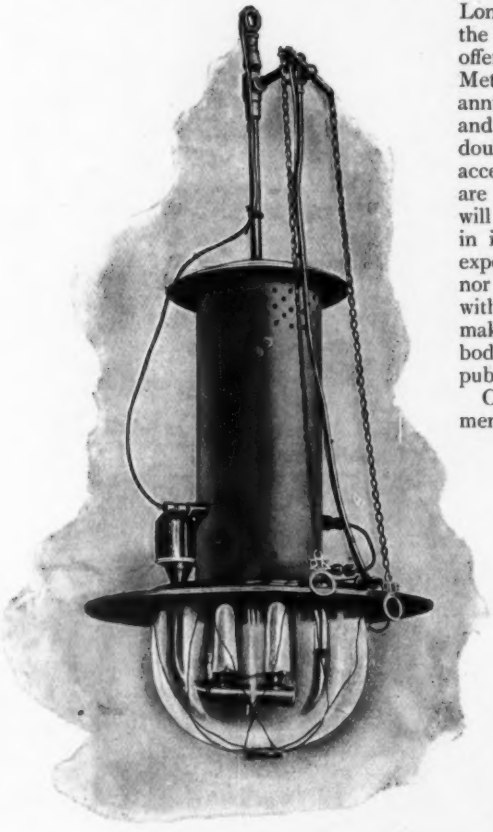


FIG. 4.—SUSPENDED TYPE LAMP.

descent principle should have the effect of increasing the advantage derived in this respect.

So far as first cost is concerned, the Kitson system for street lighting has the recommendation that no central plant is required for the operation of the lamps. It is only necessary to dig a hole in the ground, and to put up a post with an oil tank in its base. No underground pipes or conduits being necessary the expense and inconvenience of tearing up public thoroughfares is obviated, a boon that would be particularly appreciated by Londoners. The statement is made by the Kitson Company that they recently offered to light the streets of the Metropolis "for less money than is paid annually for tearing and repairing the roads and interfering with the traffic." No doubt such an arrangement would be acceptable to the public at large, but we are not quite sure that local authorities will be able to find any material advantage in it, because they are not put to the expense of "tearing and repairing" roads, nor do they pay anything for interference with traffic. The cost of opening and making good paving falls upon other bodies, and inconvenience upon the public.

One important matter remains to be mentioned, and that is the safety of the Kitson system. Obviously one of the first requisites for a new system of lighting is that it should present no greater element of danger than is evidenced by its rivals. On this point, we may quote from a report made by Dr. Boverton Redwood and Professor Vivian B. Lewes, as follows :—

> "We have given special attention to the question of the safety of the system, in view of the circumstance that the oil is supplied to the lamp under pressure, and we have arrived at the conclusion that the system is not only adapted for use in the lighting of large areas in the open air, but can also be safely employed as a source of light in railway stations, factories, and other buildings. It is, of course, obvious that safety is a relative term, and that no system of artificial lighting can be entirely free from risk of fire; but we are of opinion not only that the Kitson system may be regarded as the safest means of obtaining a given amount of light from mineral oil, but also that it is not less safe than electric light or gas."

The fact that many thousands of Kitson lamps are in use in the United States under the sanction of the insurance com-

FIG. 5.—A VIEW OF PORTLAND PLACE, WHICH IS LIGHTED ON THE KITSON SYSTEM

panies without increase of rate, is sufficient proof that no unnecessary risks are likely to be suffered. A striking proof of the safety and solidity of the reservoir—the most dangerous part of the apparatus—was afforded by a fire which took place in the Stobcross Works of the Rivet, Bolt and Nut Co., of Coatbridge, Glasgow. The reservoir was fully charged with oil and air at a pressure of 50 lbs. per square inch at the time of the fire; and, although exposed to great heat, sufficient to destroy all the fittings, the reservoir itself was removed in a blistered condition, but otherwise intact and uninjured, in the state indicated.

Visitors to the Glasgow Exhibition will probably remember that a portion of the grounds was illuminated by the Kitson light; and residents in London who are interested in the problem of street lighting may find examples of the system in Portland Place, of which a photograph is given in Fig. 5, as well as in Oxford and Cambridge Terraces, Paddington. It is also employed as the sole illuminant for the Alexandra Palace, Wood Green, and still more valuable testimony in its favour is to be found in the fact that several large engineering firms are using the system. Amongst these we may mention Sir William Armstrong, Whitworth & Co., Manchester, Messrs. Cammel & Co., Sheffield, and the North Eastern Marine Engineering Co., Sunderland.

We have now said enough to show that the Kitson system is worthy of careful investigation, and although it is not to be supposed that even the patentees hope to drive gas and electricity entirely from the field, they may reasonably expect to meet with a considerable amount of support in all parts of the United Kingdom.

W. T.

New Machinery. Appliances. Structures. & Processes.

The Editor of FEILDEN'S MAGAZINE cordially invites his readers to send him early particulars of New Structures, Machinery, Improvements, etc., for inclusion under this section. FEILDEN'S MAGAZINE undertakes the whole of the cost of illustrations, merely stipulating that proper details, photos, blue prints or tracings are supplied. Where necessary, we will send our editorial representative to inspect and report on any special subject. The Editor, however, reserves to himself the right of accepting or rejecting any matter.

THE NEW WALNEY STEAM FERRY.

THE launching of the Walney Steam Ferry No. 2 recently took place from the yard of Messrs. Vickers, Sons & Maxim, the vessel being subsequently docked at Ramsden until the arrangements for its placing on the station are completed.

Its general dimensions are as follows:—Length, 124 ft. by a width of 47 ft.; the steel hull is 72 by 38 ft., carrying two deckhouses, one on either side, each 52 by 10 ft., the 17 ft. 6 ins. space between them forming a carriage-way capable of holding ten carts. At the ends of these deckhouses are the passages leading to the side galleries (3 ft. 6 ins. wide), which extend from end to end of the hull. The deckhouses contain three general cabins, one ladies' cabin, with lavatory, captain's cabin, captain's lavatory, engine and boiler rooms, lamp room, etc. Inside, the cabins are grained and varnished, and fitted all round with sparred seats of teak, similar seats being fitted along the side galleries. The tops of the deckhouses form a promenade deck, which is also provided with seats. The carriage-way is built to accommodate ten vehicles, and is shut off from passenger spaces by gates. The prows leading on to the ferry at each end are 26 ft. by 17 ft., each containing a separate gangway 4 ft. wide for foot passengers. These are raised and lowered by means of steel rods and wire passing over pulleys on vertical standards, and connected by a wrought-steel rack. Each rack is worked by a pinion and shaft geared to a large hand-wheel 6 ft. 6 ins. diameter, and so arranged that one man can easily raise or lower the prows. The ferry is propelled by means of a chain on each side, passing over pulleys at the four corners of the boat, and once round cast-iron driving wheels, these receiving their motion by means of suitable gearing from the engines. For the sake of comparison, we give the dimensions of the old ferry now to be taken off. Length over all, 101 ft. 3 ins.; breadth, 31 ft. 6 ins.; length of hull, 45 ft. 3 ins.; carriage-way, 57 ft. long by 12 ft. wide, holding four carts; total number of passengers, including carriage-way, is about 380.

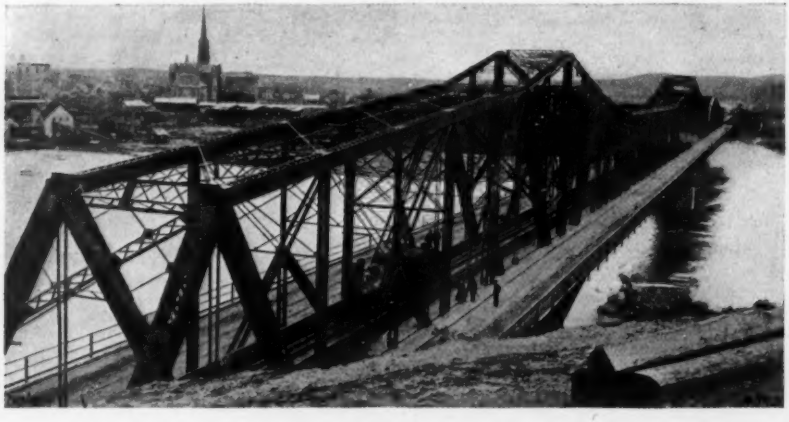
At one time it was only possible to cross Walney Channel at low water, there being then a ford where now the ferries run. At high-water people were obliged to cross in little boats. When the extension of Barrow town rendered it requisite to construct docks, it was found necessary—for the purpose of getting shipping thereunto—to dredge the channel and take away the low-water fords, in substitution of which the No. 1 ferry was introduced. The increase of inhabitants on the island of Walney and in the new part of Vickerstown—the residential quarters of the workmen at Messrs. Vickers — was the justification for the present existence of No. 2, the old ferry being quite unable to cope with the late increase of traffic. From figures got together by Mr. Bagot—the well-known collector of statistics for the Furness Railway—we learn that during the past year no less than 520,000 people travelled on the old ferry from Barrow to Walney and back, which, if doubled for the return journey, brings the amount of passenger traffic to the respectable figure of 1,040,000. It is interesting to note that whilst the No. 1 was capable of conveying 400 persons, the ferry at present under discussion is able to carry three times that number. Additionally, many improvements have been made with regard to the comfort of passengers, one of these being a covered verandah outside the vessel for shelter in times of rain. It is confidently expected that, until the erection of the long projected bridge, No. 2 will meet all requirements.

THE NEW WALNEY STEAM FERRY.

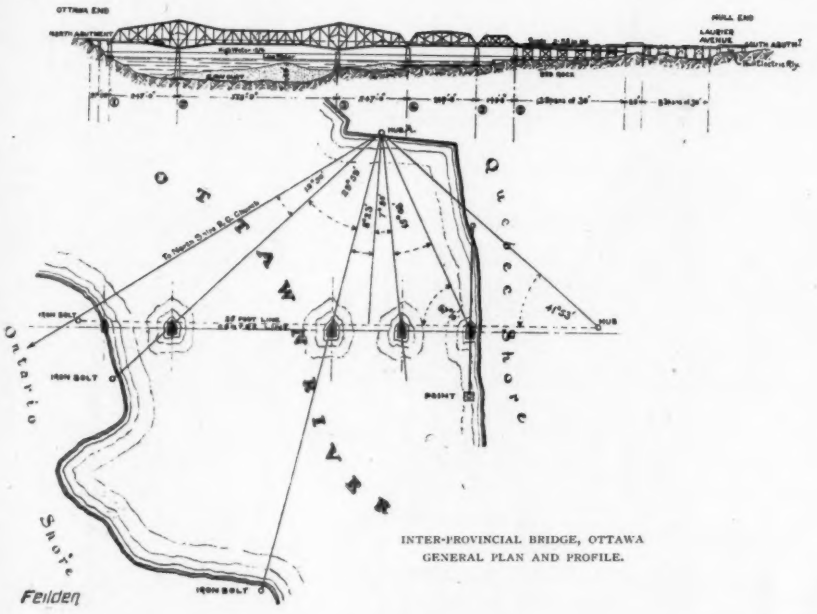
THE ROYAL ALEXANDRA (INTER-PROVINCIAL) BRIDGE AT OTTAWA, CAN.

It was thought desirable upon the consolidation—some years back—of the Pontiac Pacific Junction Railway with the Ottawa Northern and Western Railway, that these roads should have an entrance of their own from Quebec into the city of Ottawa, Ont., and for that purpose many surveys of the river were made, ultimately resulting in a decision to bring the two lines to a junction in the city of Hull, which is situated just across the river from the city of Ottawa, and across to the Ottawa shore at Nepean Point Park. The work, which was made the subject of a paper recently read by G. F. Dunn, M. Can. Soc. C.E., before the society of which he is a member, was completed about a year ago, and, including the approaches, exceeds 1½ miles in length. The main bridge (from pier 6 to the south abutment) is 1,495 ft. 9 ins. long, consisting of one cantilever span 555 ft. 9 ins. long, two arms, each 247 ft. long, one 247-ft. truss, one 140-ft. truss, and two short shore spans on the south side, respectively 27 ft. and 32 ft. long. The total length of the steel work is 2,290 ft. 9 ins., and the total width 66 ft. The distance between trusses is 24 ft., c. to c., and outside the trusses there are brackets 21 ft. long carrying two electric railway tracks and two highways for vehicles. Between the trusses the bridge carries a single-track railroad and two foot walks.

In consequence of the prevailing conditions it was considered advisable in laying out the river piers to use no base lines whatever, relying entirely on intersections, the work being laid out thus: A permanent hub was placed on a selected point on the wharf about 1,000 ft. above the bridge; the various piers being laid out on the ice, a steel ribbon over 1,000 ft. long being employed and a line run in parallel to the centre line of the bridge and 25 ft. above it. The transit was sighted on the intersection of this line with the pier longitudinal centre line, the line being produced to the shore and a permanent hub put in, or, as in one instance, a crib. All this had to be effected very quickly on account of a possible movement in the ice, but the work was checked several times with an ordinary 6-in. transit. Practically speaking, all the measurements on the structure were found to be exact. Pier No. 5 was the first one to be sunk and, owing to the shallowness of the water (which did not exceed 21 ft.), and the fact of there being but 8 ft. of sawdust at that particular point, there was no difficulty whatever in cleaning off the site and sinking the caisson to the rocky bottom. This was ready to receive concrete on February 26th, the latter process being completed by March 2nd. The next in order of construction was pier No. 4, which was built as follows: A derrick-scow was constructed and rigged up with a powerful hoisting engine and a clam-shell dredge, a channel being cut through the ice to the site, through which—though with some obstacles—(the anchor ice froze to its bottom) the scow was hauled to its location on the pier. At this point



VIEW OF THE INTER-PROVINCIAL BRIDGE, OTTAWA, FROM THE OTTAWA SIDE.

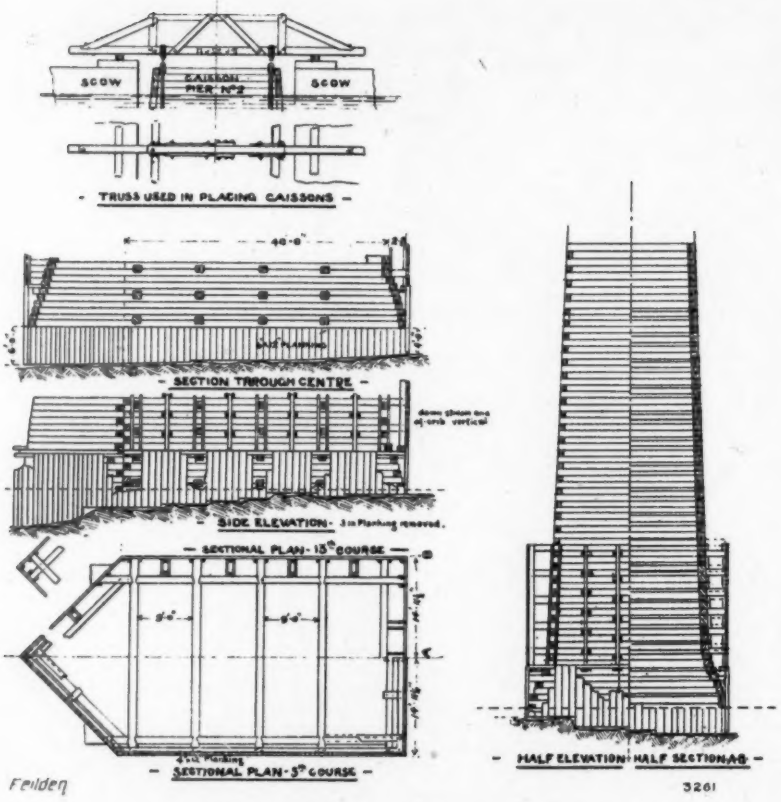


INTER-PROVINCIAL BRIDGE, OTTAWA
GENERAL PLAN AND PROFILE.

the sawdust was recorded as 17 ft. deep, and in its removal a considerable portion was deposited on the adjacent ice which the Hull residents later carried away to be burnt as fuel. The clam-shell commenced operations on February 27th, the bottom being cleaned off, and the caisson in position with a commencement of the concrete operations by March 5th.

This caisson took about four days to fill. Both this and the one for No. 5 were the ordinary bottomless type of 12-in. by 12-in. hemlock. Immediately on the completion of the concrete filling, masonry was begun on these and No. 1 erection, the last-named being a shore pier.

The depth of sawdust deposit at Pier No. 3 was quite 20 ft., with 22 ft. of water above. The clam-shell in this case could only work slowly, in consequence of the slabs getting crossways therein and allowing the sawdust to escape. Deposited into scows, the excavated material was towed to shore and dumped. During the excavation a number of giant logs were hauled out, together with a large anchor with attached chain, the links of which, however, were so badly corroded as to fall apart. This excavation was of much greater magnitude than the area of the caisson, the sides having a slope of 1 to 1. A fairly compact mass was formed by the sawdust obtained, the slabs tying it together and assisting it from falling in. The preliminary cleaning off of the foundation rock was finished, the caisson being towed into place by August 12th. Built of 12-in. by 12-in. hemlock, braced with four heavy timbers over every four courses, and tied into the sides, this caisson was of identical design with that of No. 2. On account of the depth of the water at these two piers, which was quite 46 ft. at No. 3, and 74 ft. at No. 2, summer level, they were designed in such a way as to permit all weight necessary for sinking purposes to be placed at the bottom and the outside, the concrete, therefore, not being deprived of any of its rightful area inside the caisson. It will be seen by reference to the illustration, that the upper part of this caisson was built on the same batter as the masonry, 1 in 24, but on attaining a point about 15 ft. from the bottom, the batter was sufficiently increased to permit of a wall being erected from the cutting edge up around the caisson, and tied into the main wall, thus forming a pocket capable of holding enough sinking material to lower the caisson to the requisite depth. After this had been placed approximately on the centre, sufficient sand and broken stone



INTER-PROVINCIAL BRIDGE, OTTAWA: DETAILS OF CRIB.

were deposited to lower the sinking pocket until the cutting edge was almost touching the bottom. The remaining sawdust was then removed by divers, and brought to the surface in a large bucket. After this had been accomplished, the caisson was placed precisely on the centre and lowered to the bottom. In doing this no trouble was experienced, as the bottom edge had been scored when constructed, in order to (approximately) fit the bed rock, there being no current at this point, and the bed rock here—as at piers Nos. 4 and 5—requiring no further levelling.

After all holes and crevices found around the bottom of the caisson had been carefully packed by divers, the concrete was deposited. This (as well as that used at No. 4 and 5 piers) was composed of one of cement and one of sand to about five of broken stone. This last-named was not screened, as, after testing the stone chippings by using them instead of sand in briquettes, the result was found to be perfectly satisfactory.

At piers Nos. 4 and 5 the concrete was hand-mixed, that at pier No. 3 being manipulated by a mixer; in this case a horizontal cylindrical machine of about 14 ft. long, with a shaft running longitudinally through the centre, to which a number of paddles were attached. It was fixed on a scow alongside the caisson, the cement, sand and stone being supplied by carriers on endless chains, the water being obtained from a tap controlled by a man. The cement and sand were first allowed to enter, being thoroughly mixed before reach-

ing the point where the stone and water entered nearly simultaneously. Everything was then very completely mixed, and ultimately ejected from the cylinder into the depositing kibble. No measuring was required, the carriers being set at their proper proportions before the machine was started, and all working from the same gearing.

The construction of the pier No. 2 caisson was commenced on the Hull shore, being then launched and towed over to the quiet water below Nepean point, where it was completed. This caisson was, from top to bottom, about 76 ft. in height, being, as before mentioned, of similar design to No. 3. The excavation of the sawdust by the clam-shell commenced on September 2nd, the plan of operation being that employed at No. 4. In consequence of there being a swifter current, however, a greater area had to be excavated before the placing of the caisson could take place. At this point the sawdust was 15 ft. deep, above being 57 ft. of water. Two scows, 80 ft. and 20 ft. each, were placed at either side of the caisson, a truss being built from one scow to the other at each end, and the caisson suspended therefrom by heavy cables, sufficient ballast having previously been placed in the sinking pocket to ensure steadiness. They were towed into position on September 16th, the current running at about three miles an hour. Cables were then stretched from the scows to rock bolts, and to No. 1 pier (on the Ontario shore) to two weighty ship anchors on the river side and up stream to a large Chinese anchor, the cable from this anchor entering the caisson's bow at some distance below water level. No dragging is said to have occurred, although all the anchors were bearing on sawdust *débris*. The caisson being lowered to the bottom, divers were sent down for the removal of the balance of the sawdust. By them the shore slope of the rock was found to be unusually smooth, extending some distance into the caisson. It was therefore resolved to blast this section from one end of the caisson to the other, and with this intention a steam drill was first brought into requisition, a line of holes being drilled at about 5 ft. apart at a 2-ft. depth. They were loaded by a diver, and fired from the top by the battery. The loose stone being then removed, the caisson was fixed in position. Although almost to an inch on the centre both ways, it was nevertheless difficult, owing to its extreme height, to ascertain as to its being plumb. However this was satisfactorily checked in the three following ways:—Firstly, by a level across the caisson; and secondly, by its batter, by running a straight-edge down the side. The third test was applied because, owing to the great height of the structure — nearly 80 courses of timber—the two first named were considered to be insufficient. Therefore a plumb bob was obtained of about 50 lbs. weight, this being lowered 50 ft. from the inside edge of the caisson on both sides successively. A diver then measured from the sides of the caisson to the cord with a stick, the result of the experiment being that the caisson was found to be practically perpendicular. All crevices at the bottom were then packed with bags of neat cement. The concrete for the lower 25 ft. of this pier was mixed with the machine described, the specifications being altered to one of cement. When 24 ft. of the concrete portion of the pier had been deposited an accident happened to a large bridge under construction, in which a number of men were killed. This was followed by orders from the Dominion Government to suspend work, whilst the companies were held to a certain clause in their specifications, which provided that the caisson might be pumped out and the remaining concrete deposited dry. To do this as matters stood was impossible, and it was not until March of 1899 that the Government gave its permission to proceed with the work, conditional on satisfactory core being produced through the 25 ft. of concrete to the bed rock.

(*To be concluaed.*)

The National Physical Laboratory.

THE commencement of a new epoch in British industrial methods has been inaugurated by the establishment of the National Physical Laboratory at Bushey House, Teddington.

It is as strange as lamentable that such an institution should have been lacking for so long in a country such as ours, furnishing incontestable proof that the warning, "Britons, wake up!" is no supererogation. Our behindhandedness is clearly demonstrated in this particular instance, for the city of Berlin has been able to boast since 1883-7 the possession of its Reichsanstalt, an imperial undertaking equipped and maintained by the Government for the purposes of similar work.

The *raison d'être* of the Laboratory may shortly be stated to be this—to make the forces of science available for the nation, allying them with commerce and industry, and to break down the barrier existing between *theory* and *practice*: in brief, to regard science as a commercial factor. During the past years the successful following of many remunerative trades has been lost to England solely because of the lack of uniformity in our methods of manufacture, and the lack of proper scientific equipment. The National Physical Laboratory at Teddington is going to change all that. Its object, of national importance, is to be the bringing back of lost trades to this country.

The scheme for such an institution in England was first outlined by Dr. Lodge, rather less than ten years ago, in an address given before the British Association. A committee was formed, and discussions took place, but a want of funds aborted the project. It was then thought to be useless to approach the Government, and the affair was therefore dropped. Later Sir Douglas Galton made himself champion of a seemingly lost cause. His opinion on this national subject may here be quoted:—"Formerly our progress in machinery was due to accuracy of measurement, and that was a class of work which could be done, as Whitworth showed, by an educated eye and an educated touch. But, as we advance in the applications of science to industry, we require accuracy to be carried into matters which cannot be so measured. In the more delicate researches which the physical, mechanical, and electrical student undertakes, he requires a ready means of access to standards to enable him to compare his own work with that of others. My view is that, if Great Britain is to claim its industrial supremacy, we must have accurate standards available to our research students and to our manufacturers." Thus he constantly drew attention to the pressing need for an English Reichsanstalt, with the result that a second committee met and reported at Liverpool. A plan of organisation was made, and was followed by a petition to Lord Salisbury. The happy consequence of this step showed itself in the formation of a Treasury Committee, with Lord Rayleigh in the chair. Their unanimous report was "that a public institution should be founded for standardising and verifying instruments, for testing materials, and for the determination of physical constants"; the result being the establishment of the present institution, opened on March 19th by the Prince of Wales. But the sum granted and the annual £4,000 income are altogether inadequate for the proper maintenance of such a laboratory, and it is to the public that those interested are looking for encouragement.

Bushey House, the site chosen (formerly a Royal residence), is a solid and substantial building well suited for the purpose. The basement and ground-floor have been given over to the Physical Laboratory, the former being covered with a brick groining, on which the main structure rests. Four extensive corner-wings, without any basement, are employed for the electrical and magnetic, thermometric, metallurgical, and chemical laboratories, a number of constant-temperature rooms being in the basement. These latter will be completed with a measuring machine, a dividing engine, and a comparator; whilst in an adjoining room the resistance measurements of the British Association committee will be continued, and yet another appliance for the production of liquid gas is being set up.

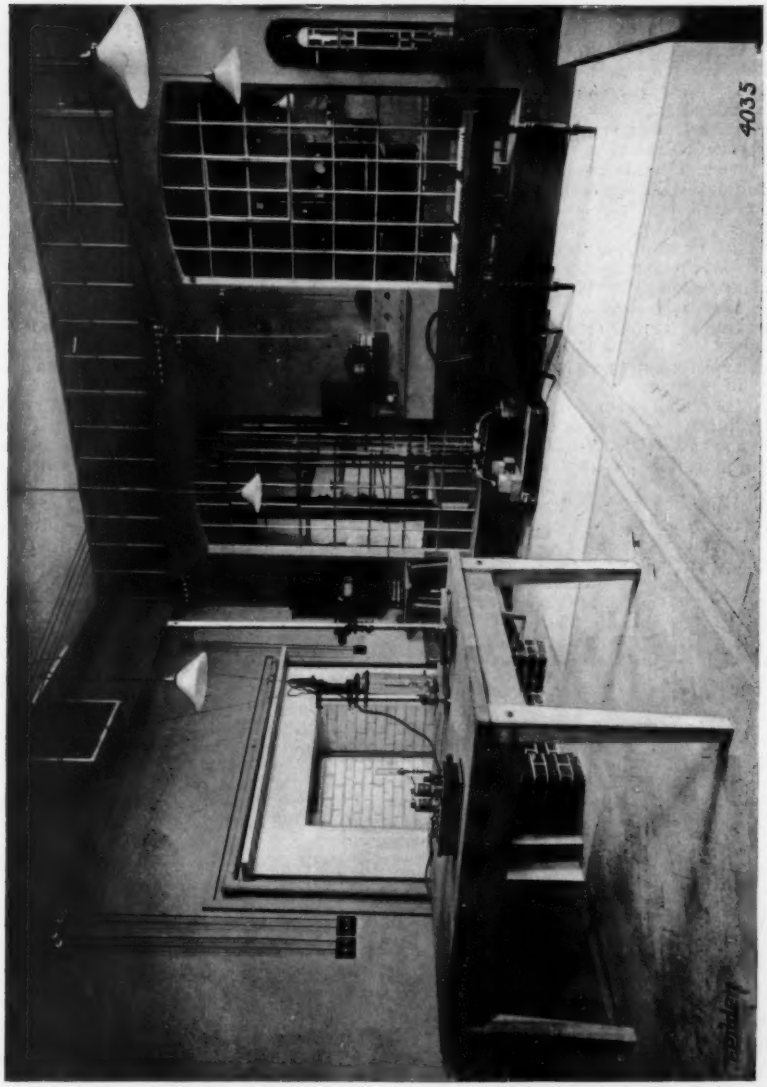
The first-named laboratory, which includes the original dining-room and library, contains the Lorenz apparatus for the absolute measurement of resistance (presented by the Drapers' Company in commemoration of the late Principal J. V. Jones, F.R.S., of Cardiff), with other apparatus for the absolute measurement of current and electro-motive force. So far as has been possible, all iron has been removed from the structure; and with the purpose of preventing a stray magnetic field from any currents used, concentric wiring has been employed for all large currents, while those for smaller currents have been twisted. The historical standards of the

SUP

Photo by *Elliott & Fry.*

R. T. GLAZEBROOK, D.Sc., F.R.S.

Principal of the National Physical Laboratory.



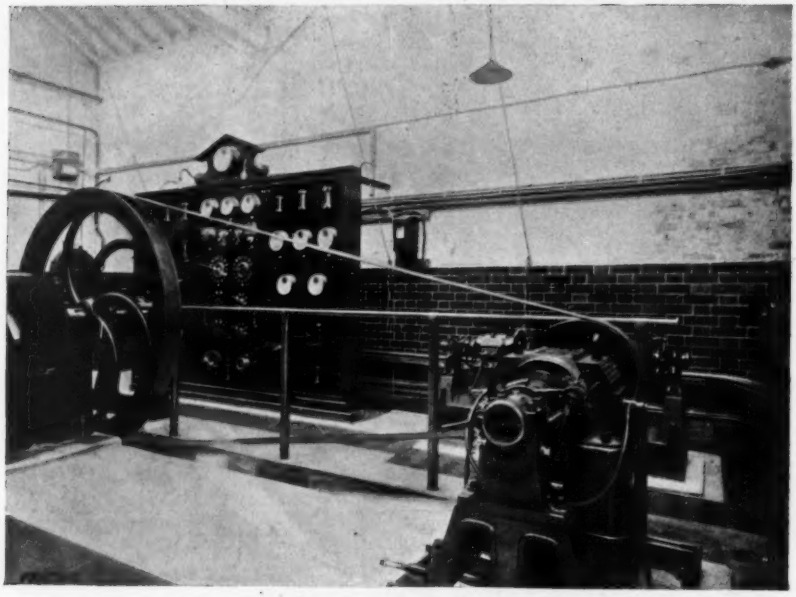
BUSHEY HOUSE: THE THERMO-METRIC LABORATORY.

furnished with the requisite appliances for cutting and polishing sections, further photo-micrographical examination having been obtained. So far, the laboratory provided for photometric measurements is unequipped.

A most important branch of the great work is the engineering department. This laboratory is a building 80 ft. by 50 ft., adjoining the power-house, both being newly erected round the old laundry. This latter is divided into two bays, a shaft driven by a motor (supplied by Mather & Platt) running

BUSHEY HOUSE: THE CHEMICAL LABORATORY

along one, whilst the other (for experimental work) is traversed by a 2-ton crane. A testing-machine and machinery for testing steam-pressure gauges, indicators, and such like instruments are in evidence. There will be carried out in this department the tests on the strength of materials with, possibly, the commercial testing of the magnetic properties of iron. As at present there is no place in Great Britain where such tests of pressure gauges or steam-indicators can be taken, the immense value of



BUSHEY HOUSE: THE POWER ROOM.

the projected work will be immediately perceived. The tests of pressure and vacuum gauges may be divided into three classes: (*a*) a direct comparison with a mercury column, or with a weighted piston throughout the whole scale; (*b*) a comparison with the laboratory standard gauges throughout the whole scale; and (*c*) a comparison with the laboratory standard gauges at two or three pressures in the neighbourhood of which the gauge is commonly used. The laboratory standards are tested frequently against the pressure column or weighted piston. The mercury pressure column to be erected, is 50 ft. high, giving a pressure of about twenty atmospheres. Necessary pumps are fitted, and a lift will be set up along the column for the observer to read the height of the mercury. The testing of pipes and cylinders by hydraulic pressure, up to 10 tons per square inch, can be carried out in the laboratory. For the gradation of standard gauges, after the twenty atmospheres, recourse is to be had to some multiplying device.

In the observatory department the testing of meteorological and other apparatus will be carried on, as heretofore; the work for the present being continued at Kew.

Gas and water with electricity have been laid on freely in the building, a 100 volt circuit connected to the main dynamo and battery in the power-house supplying the light. Numerous plug-points enable a supply to be taken off for lights for experimental purposes or for small motors; whilst, for experimental work, a special battery of fifty-five cells has been installed, this being divided into groups of five. Wires run from the switchboard to the different rooms in such a manner that one or more of these groups can be switched on to any circuit; voltages of between 10 and 110 volts being in this way obtained as required. The heating of the house is on the Webster low-pressure system, by steam from a Lancashire boiler in the boiler-house, situate at a distance of 100 yds. This boiler also supplies steam to one of Parson's 60-kilowatt turbine generators, this being the main source of power. The power-house is also equipped with an 18-h.p. Crossley gas-engine, driving a 12-kilowatt dynamo (by T. Parker & Co.). This serves as a stand-by, and also for charging the main battery of 58 chloride cells.

WORKSHOP PRACTICE

Practical suggestions for this section are invited, which, if accepted, will be suitably paid for. Wherever possible, drawings should accompany the contribution; rough sketches will suffice. Nothing will be too poor for a careful inspection. See important announcement in advertisement pages.

Making Formed Coils for Armatures. — In winding armatures it is best to keep to as small a variety of windings as possible. I find, for continuous-current drum armatures, that two kinds are enough — viz. the ordinary lap or wave-drum winding for large armatures, and the "Eickemeyer" coils for small armatures. Having fixed what kind of coils you intend using, the next thing is to design a former which can be made quickly and cheaply. Let us take the ordinary drum-winding. Having the pitch of the winding, we must see how far beyond the armature core the ends of the coils must protrude so as to get them all in. The following rule is one which I use. The sketch will explain:—

$$\frac{(\text{No. of coils} \times t) + 10\%}{\text{Total circum. at } C \text{ or } D} = \text{Sine } \alpha$$

t = thickness of bar.

Then get a pitch-pine board and mark off the length of armature core, and on these lines mark off the pitch of coils measured round the circumference, and at these points set off the angles αC found by the formula (the left half of board is raised equal in height to the depth from bottom of top bar to bottom of lower bar in slot). Draw a line joining the pitch divisions. Now get pieces of hard wood about 2 ins.

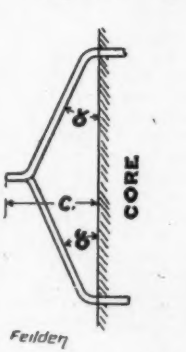
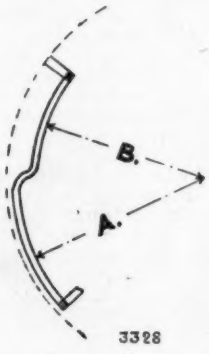


FIG. 1.



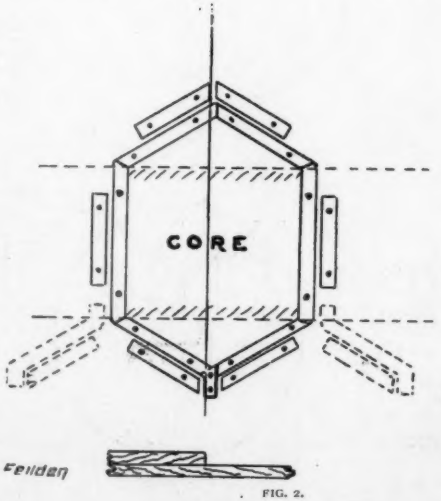


FIG. 2.

FIG. 3.

MAKING FORMED COILS FOR ARMATURES.

wide and equal in thickness to depth of bar and screw them inside the lines drawn on board (see Fig. 2); then screw pieces outside these, leaving space for bar between and leaving the corners of inner pieces clear, so that you can get to hammer the bars round the corners. This arrangement is for lap-winding; but if wave-winding is wanted, the pieces shown dotted would be screwed on, instead of those turned inwards. Fig. 3 shows a diagram of windings when finished. After the former is made, we cut the bar to required length and bend it in the centre edgeways, thus (Fig. 4). It is next fastened in a vice at end *A* and bent, as in Fig. 5, to an angle to suit former; it is then put on the board and bent round the hard-wood pieces by hammering and pliers, etc. The next thing to be done is to bend the coil to the radius of the armature, and is done this way: Get a block of hard wood of a convenient size and describe an arc equal in radius to armature, and another of less radius, leaving the difference equal to depth of bar, thus (Fig. 6); then, with a band-saw, saw out to the lines. Keep the piece *A* and set off a line equal to the angle α of formula, and saw it through; then screw the two pieces back on to the block they were sawn off, leaving a space between them equal to thickness of bar; the piece *B* is thrown away. Now, by placing the ends of the coil in the groove *C* and hammering with a mallet, it will bend it to the required curve. This completes the coil as far as forming is concerned. I will now endeavour to explain how to make the Eickemeyer coil, in which the ends, instead of protruding over the end of the armature core, are turned down at right angles, thus (Fig. 7). First describe a circle equal in diameter to armature, and mark off on the circumference the pitch of coil; next calculate the depth *A* by the formula used before, and mark it midway between the pitch points, and between these points describe a spiral curve, thus (Fig. 8). It is a good plan to bend a piece of copper strip over the drawing and then straighten it, and thus get the length of the wire of coils at end of armature. Now get a board and mark off the length of armature core (Fig. 9) and each end of core, allowing for insulation plus depth of bar; draw a line, and on these screw a piece of vulcanite fibre $\frac{1}{2}$-in. by $\frac{3}{4}$-in. deep by the length of the outer spiral at end of core less twice the depth of bar; then start to wind the wire around these strips from *A*, following the arrows to *B*. Now the coils are flat, and if they are multi-turned coils should be taped. Take coils off the board and bend them on a block of hard wood cut thus (Fig. 10), curved same

FIG. 4.

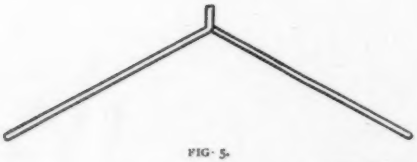


FIG. 5.

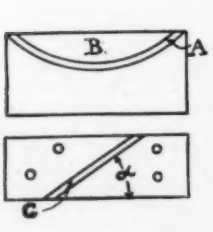


FIG. 6.

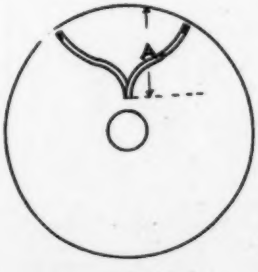


FIG. 8.

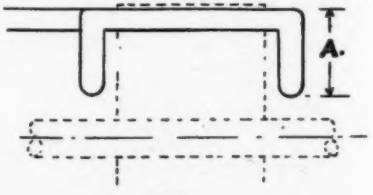


FIG. 7.

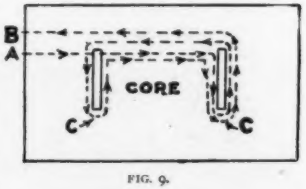


FIG. 9.

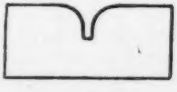


FIG. 10.

MAKING FORMED COILS FOR ARMATURES.

as Fig 8. by placing them with the points *C* in the groove in block and opening the top and bottom bars away from each other, and then hammering to block ; then, with a pair of pliers, bend the top edges of coil to the slot ; this completes the coil, and the loose ends are bent down to commutator either as a lap-winding or a wave-winding.

MECHANIC.

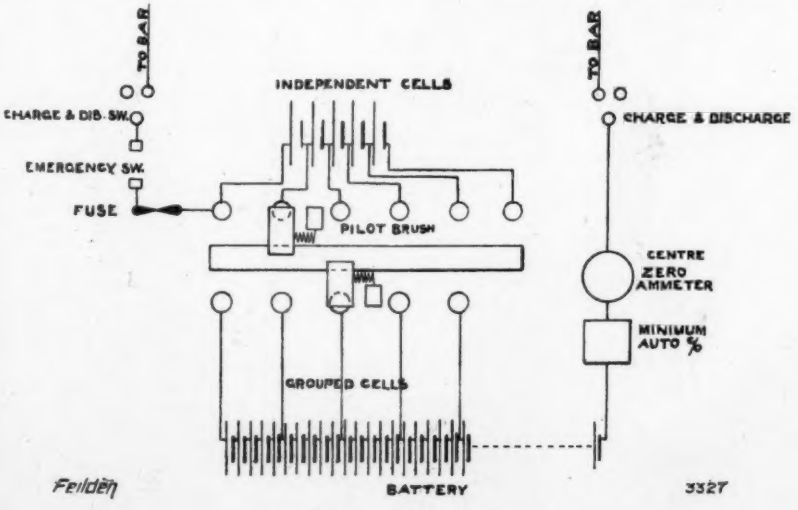
A Dynamo Trouble.—We had been running for some considerable time a dynamo with a Gramme ring armature made by a first-class firm about twelve years ago. On starting it one day an intermittent arc was observed in the space between the inside of the ring and the shaft. Shutting down and testing for earth failed to reveal any fault, nor was anything unusual to be seen on examination with a lamp. On another attempt being made to start, the same trouble manifested itself. It was at last discovered that in balancing the armature, instead of drilling the pulley in the usual manner, a piece of lead had been inserted inside the ring, and having worked loose had damaged the insulation of some of the conductors, thus causing the arcing at a certain point in each revolution.

DUNELMAN.

Re **A Unique Telephone Fault.**—In your December, 1901, issue of FEILDEN'S MAGAZINE, I notice a letter from one of your correspondents under the above heading. I beg to point out that I have been engaged for the last two-and-a-half years on telephone repairing and fault finding, and have often come across the fault mentioned. It mostly occurs in damp places, where the soft iron cores of the receiver bobbins have their polar faces covered with rust ; this is scraped off, as it damps the action of the diaphragm and causes faint speaking. In scraping off the rust, minute particles of iron are also scraped off, and if these are not properly cleared out of the receiver case by a dust brush or duster, they in a very short time fill up the air space between the polar faces and the diaphragm and cause faint speaking, and in some cases the speaking is stopped completely. There is also another fault mentioned in the same issue—*i.e.* buckling of the diaphragm. This often occurs, and is due to two causes—first, the diaphragm being too thin for the strength of the magnets employed (this may be eliminated by using a thicker plate of iron) ; second, clerks or office boys tapping the diaphragm with a lead-pencil or pen-holder with the idea that they will make it speak louder.

TELEPHONE INSPECTOR.

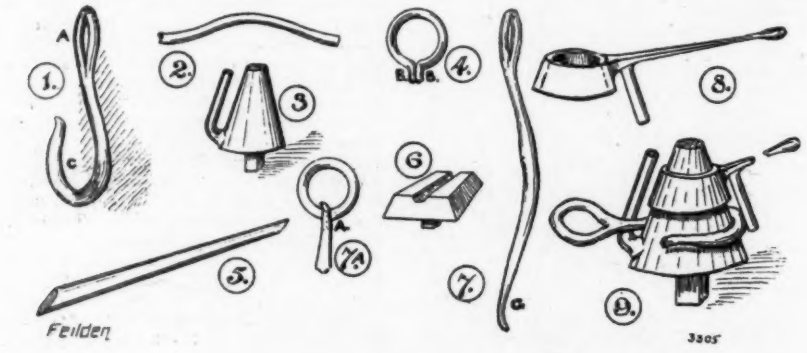
Grouping of Regulating Cells.—Regarding the above subject, I do not think it gets the consideration due to it at all. In power stations the main switchboard is usually

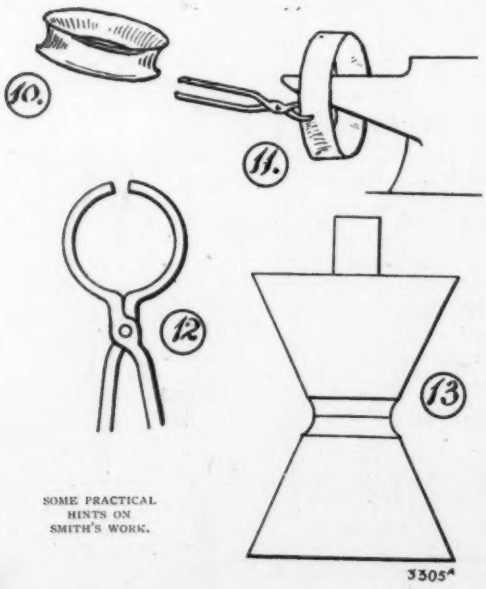


GROUPING OF REGULATING CELLS.

placed as near the battery room as is convenient, but even then the amount of copper required for connecting the cells to the regulator is quite a considerable factor in the cost of the battery or switchboard as the case may be. Then again when the regulator is close to the regulating cells and worked by shafting from the switchboard, which is at some distance, the system is anything but perfect. The shafting is very often run in some out of the way place, inconvenient to get at and keep in order, with the result that it often becomes unworkable. An indicator is generally placed on the switchboard to shew the position of the sliding contact, but owing to the "back lash" in the gearing, this is often useless, not giving even an approximately correct reading.

I think that by grouping the regulating cells in sets, the battery could be more easily handled and the initial cost greatly reduced, both as regards copper and the regulator itself. Suppose we take the case of a battery having 30 regulating cells, and the average length of conductors from these cells to the regulator 50 feet. This would require 1,500





SOME PRACTICAL HINTS ON SMITH'S WORK.

feet of copper, usually solid rod. Now by grouping these cells in sets of 5, this could be reduced to about 500 feet, or exactly a third of the former. This is by no means the greatest possible reduction that could be made. If the independent cells shown in the diagram were placed close up to the regulator, a further reduction of about 40 per cent. could be made. This does not take into account the cleats, supports, insulators, etc., necessary for the running and fixing of the conductors, which would again show favourably in the case of grouping, in the same proportion.

With regard to the regulator itself, instead of this becoming a delicate piece of apparatus with a complexity of connections, it is simplicity itself, and could be made vastly cheaper than the ordinary regulator. It could always be on the front of the switchboard in sight, thus preventing any danger of shortcircuiting any individual cell, which in itself is clearly an advantage over the gear-worked

one. The cells themselves could be kept more uniformly charged, and the range of regulation could be easily increased.

I have not gone into the actual costs, but have merely drawn a comparison between the two systems, and not an exhaustive comparison at that, but just mentioning one or two of the chief items.

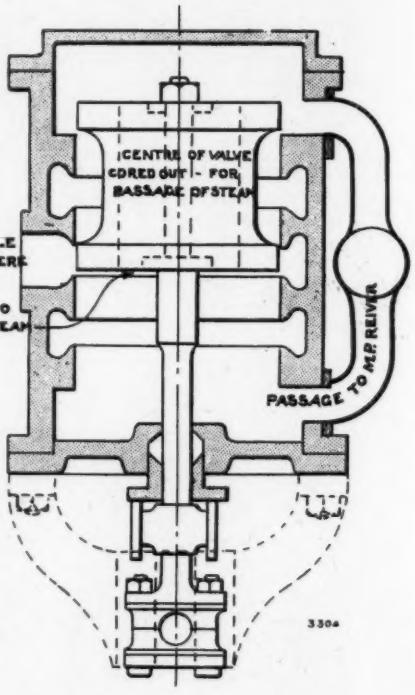
I think that even without taking into account the first cost, the grouping system possesses many advantages over the present system, and is at least worthy of more consideration. "BOOSTER."

[WE should be glad to hear from other Central Station Engineers, on the above. A large number of the smaller stations are now run with accumulators, so that there must be many of our readers who have experience on this. ED.]

Some Practical Hints on Smith's work.—One of the most interesting, and certainly the least understood or practised, is that branch of smithing exercised in ship-tackle making, and by illustrating the forging of a few examples the methods will no doubt be found advantageous if applied to other or similar kinds of work. The tackle hook (Fig. 1) is a good example for showing the manner of welding an eye to a shaped body, so that it shall not be pulled off when bending. The eye *A* is first bent in the form of Fig. 2, then brought round the finger-peg, Fig. 3, so as to form it as in Fig. 4. It has then to be welded together at the open ends *B B*, and shaped for shutting on to the body *C*. Before welding the body to the eye cut the end of the bar slantways as Fig. 5. The advantage of this shape will be seen if, when welding it to the eye, the smith strikes the point with the ball end of his hammer, so as to fill in the division of the open ends of the eye, thus forming a hook shape split, Fig. 7 *A*, which will not pull out when it is bent on the finger-peg. When the body has been welded to the eye and rounded up by means of a pair of tools as in Fig. 6, it is then slightly curved, as in Fig. 7, by bending on the anvil horn. It has then to be cut off the bar slantways as before, ready to weld to another eye if necessary, and also to facilitate pointing the end *g* (Fig. 7). It will be then ready to be bent into its proper shape as in Fig. 1. This is accomplished by means of the peg lever (Fig. 8). The forging is placed in the finger-peg (Fig. 9), the ring of the peg lever is put over the body of the hook with the peg at the back, and then to be pulled round the finger-peg. The curved point *g* (Fig. 7) is brought to its proper shape by rounding up on the peg with the hand hammer. For bending larger hooks, use an extra loose ring on the finger-peg, and for smaller ones use a loose ring on the finger. The taper of the peg will allow for this. Another example of forging will be a rope thimble (Fig. 10). Cut off the required length of strip iron, hold it in the centre by means of a pair of point bit tongs, bend the ends and shape and weld on the anvil horn, as in Fig. 11. The groove is formed by means of a pair of round-bitted tongs shaped as Fig. 12, and placed in a pair of tools (Fig. 13) in a fly-press and squeezed to shape. F. E. THOMAS.

Compounding a Triple. — Occasion had arisen on one of our cruisers to remove the high-pressure piston from our port main engines. The ship at the time was at a station on the borders of the tropics, and at a season of the year when everyone was looking for the shady side of the deck. We had just anchored in the harbour, and as soon as steam was shut off the work on the main engines commenced. We soon had the cover off, and the work of removing the big 6-in. nut from the end of the rod was then claiming all our attention. After a quarter of an hour's hard work it made a start, and we thought luck was on our side. It made one turn and then refused to budge ; the thread had seized, and we were in a fix : to make matters worse an unexpected order came down to say we were to leave in the morning. All that night we toiled to move that nut, the already stifling heat of the engine room was increased by the fire we built up round the nut, but all our efforts failed. We left in the morning with our starboard engines working at their hardest, while every effort was to be made to get the disabled port ones to work again. To work them as they were was out of the question, with the piston slack on the rod, so that our only course left was to compound. We first removed the connecting-rod, and then turned our attention to the removal of the high-pressure slide, which was of the piston type, taking primary steam on the inside. This, like the nut on the piston-rod, refused to leave the rod, so we were forced to look round for other means of getting initial steam to the m.p. receiver. By taking measurements we found that by removing the guide brackets from the slide-rod, we could raise it enough to give an opening to steam. The valve was raised and kept up by a set of Weston chain-blocks, after having removed the link motion. On steam being admitted by the throttle it passed into the h.p. receiver by the opening given, due to lifting the valve ; the pressure being

equal on both sides of the h.p. piston, no movement of this could take place. The primary steam, by this arrangement, was thus able to reach the m.p. receiver, which took the place of the h.p. cylinder, making our engines compound instead of triple expansion. A reference to the sketch will make it plain how the change was effected, the dotted portion being the guide brackets which had to be removed. On our arrival in harbour the covers were again removed, the piston-rod nut drilled and cross cut off, a spare one fitted, and the rest of the motion being restored to their original places, brought us to the end of what had been a rough job. I might add that the engine was 5,250 h.p.



A. E. W.

Pattern for Locomotive Smoke Pipe.—In the side view it will be noticed that the right-hand half, which is in section, appears as seen from the front of engine, and that of the left shows outline view as seen from the side of same. Formerly the upper part was made separate from that seated on the boiler, but lately the practice is as here shown, with bolt holes cored, and it is expected to fit pretty close to its seat as the casting comes from the foundry. There is about $\frac{1}{4}$ in. allowed for chipping strips. The pattern is made in three pieces. The upper part, with core print added, is made to joint endways on the line *Y*—*Y*. Above that line the outline curve is uniform. The next part is that between *Y*—*Y* and the broken line marked core print, and is best built up of segments instead of staves, taking care to save material where possible, as, owing to the variable curve, the whole of this portion must be worked by hand to finish with the top side of flange, which must also be parallel in thickness. Then the part beyond, with core print attached, is added, and secured with screws, the pattern parting lengthwise in the same plane as the sectional view on right, each half being kept in relative position with dowel plates. Fig. 2 shows the core-box for the recess *R* and underside of the flange. The core-box is made for only one-half of the circle; two cores from the same box complete it. In making the principal core the moulders use green-sand only, and require the one half-box, with half-discs fastened at both ends, the upper half of core being swept up with a "strickle," with its ends resting on the half-discs mentioned, and a stop at one end as a guide to keep the upper half symmetrical with the lower half. On account of the rough usage and the heavy grid used to carry the core, extra pains are taken to make the box strong, which is made up of lags resting in supports set about a foot apart. Each support is carefully drawn out to a semicircle, and set about 2 ins. from the ends of the lags, allowing about $1\frac{3}{4}$ ins. of stave on each side. By having them, say, 1 in. thick, it leaves but little to pare away with the gouge. The above is made in two lengths, parting at line *X*—*X*, which is at the narrowest part of interior. I should have said that in turning the core prints care must be taken to have them taper the same as the inside, so that the two parts of core-box may be straight from end to end. Fig. 3 shows the method of finding the different points in plotting the curve to the flange, or any similar work where one cylinder standing at right angles to another has to be joined. The prints for bolt-holes are put on the outside only. Provision must also be made to allow the thin facings surrounding the holes to leave the sand where there is back draft. One way is to increase the angle of one side, which will

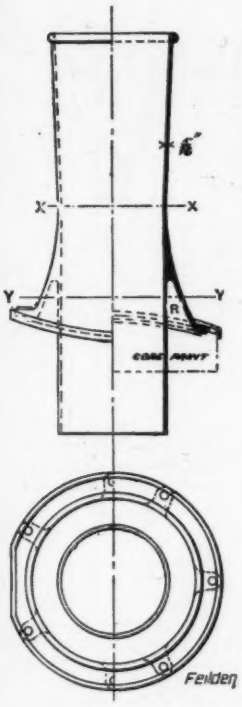


FIG. 1.

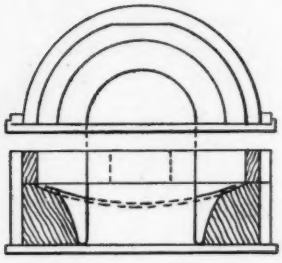


FIG. 2

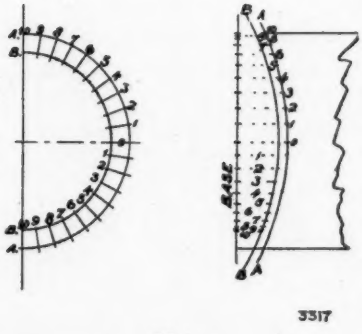


FIG. 3.

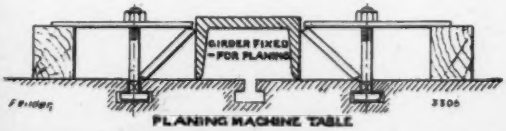
PATTERN FOR LOCOMOTIVE SMOKE PIPE.

distort the shape, but is the quickest way out of the difficulty. WM. NEWTON.

[Our contributor does not say how the end of the body core is supported at the joint line X—X; but we are of opinion that a much better result would be obtained by using a core "struck up" and dried than by one made in "green sand," with the top half "strickled" to shape.—ED.]

Cramping Heavy Jobs to Planer Table.—Having a large number of channel girders to plane, we adopted the following method, as shown by sketch:—Short pieces of iron of rectangular section were set up at about an angle of 45 degs. with the table, with one end against the bolts fixed in the T slots of the table. Suitable pieces of wood packing supported the ends of each cross cramp, tightening them by the holding-down bolts, to effectively withstand a heavy cut. It is advisable to fix some short cramps at the ends to take off the longitudinal strain.

HENRY L. BEARE.



CRAMPING HEAVY JOBS TO PLANER TABLE.

Lubricating Rings.—At Figs. 1 and 2 are shown two different forms of lubricating rings designed to revolve on the shafts of motors and other bearings requiring a copious supply of oil. Fig. 1 is intended to be provided with cored internal recesses which carry up the oil to the periphery of the shaft. The second form

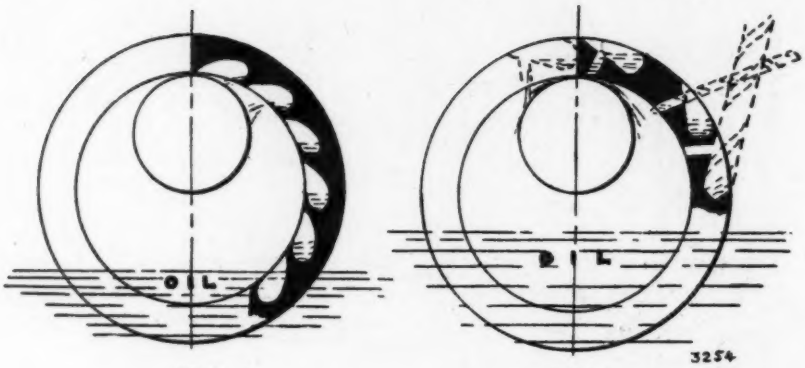


FIG. 1. FIG. 2.

LUBRICATING RINGS.

s arranged with external cups, formed with a twist drill or cutter on the outside of the ring, a smaller hole, as shown, being drilled through the ring to allow the exit of the oil, as the cups are brought into a vertical position. TIPTONIAN.

[We fear from personal experience that sufficient friction would not be induced to raise the loaded side of the ring to the top. —ED.]

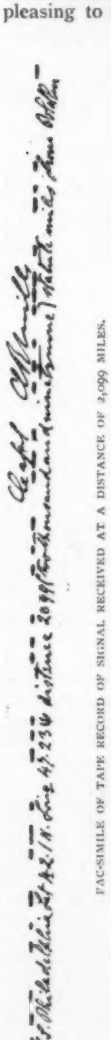
INDUSTRIAL PROGRESS

ENGINEERING NOTES — FROM ALL SOURCES.

The Healthiness of Gas Lighting.—With reference to Mr. Harman's remarks on this subject, published in our March issue, we have received a communication from another correspondent, Mr. F. H. Lester. Mr. Harman, it will be remembered, argued that, as people are in some cases ordered treatment with sulphur in hot springs or in tunnel air, the public should not regard any sulphurous odour as a nuisance, but rather as a disagreeable form of free medicine. The principal sulphur compounds produced by the distillation of coal are CS_2 and H_2S. In the purifiers the gas is freed as far as possible from these by contact with lime or ferric oxide. Traces, however, of both these compounds manage to escape, the CS_2 being especially hard to get rid of, on account of its volatility. With the gas burning in the consumer's room, the CS_2 and H_2S are, if present in the flame, almost completely decomposed, each giving off SO_2, mixed, of course, with the CO_2 of combustion. How the existence of SO_2 is absolutely unhealthy, whilst of the danger of H_2S it is not necessary to speak here. It is granted that SO_2 vapour baths may benefit some diseases; but, it is asked, does Mr. Harman argue therefrom that the ordinary healthy individual would derive advantage from a similar treatment? Let sulphur, it is urged, be taken when required in the form of the harmless lozenge. Again, the above-named compounds are ruinous to books, paintings, or furniture; whilst, as to the alleged promotion of ventilation, the combustion of gas certainly does so, in cases where the burner is placed in the roof. But the sole effect of gas, as used in ordinary rooms, is to load the atmosphere with hot CO_2, and so render it unwholesome. In those public buildings heated by other means than fires, the lack of ventilation, when electricity is employed for lighting purposes, is usually due to the absence of any means of egress for the heated air at the top of the building. Were these provided, and, wherever possible, fans placed therein, there is no doubt whatever but that many of our public rooms would become as pure as Nature requires. Our correspondent maintains that, where gas must be employed, the products of combustion should be led into the chimney as from the fire; for it is in this way only that we can hope to secure the benefits of light and ventilation.

Steam Turbines on the Electric "Underground."—The British Westinghouse Electric and Manufacturing Company have received the contract for the supply of the whole of the power equipment to be put down in the electrical generating station of the Metropolitan Railway. The main generators will consist of three-phase alternators direct-coupled to steam turbines, and three of these sets, each of 3,500-kilo-watt capacity, are to be put down at the Metropolitan Company's works at Neasden. The British Westinghouse Company are also providing similar machinery for the District Railway Company, four turbine-alternator sets of 5,000 kilo-watts being the arranged instalment for their works in Chelsea. In both cases the energy will be generated in the form of three-phase current at a pressure of 10,000 volts. Sub-stations are to be put down and equipped with transformers and rotary converters for reducing the voltage and for converting the alternating current into direct current for use on the train motors. The use of steam turbines in such large units for the generation of electric power is a distinct departure from ordinary practice, and the behaviour of the power plants of the "Underground" will be watched with the greatest interest by all power engineers. The steam turbine certainly has many important advantages over the reciprocating steam engine for electrical work; some of these advantages are: small size for power, high speeds whereby size and cost per unit output of the electric generator are reduced, absence of vibration, small foundations. The Westinghouse Company have for several years been at work on steam turbines, and have succeeded in producing a form which is remarkably economical, and can be built for very large powers. It is expected that the

bulk of the plant will be manufactured at the new Westinghouse Works in Manchester, which are now practically completed. It is pleasing to note that the Metropolitan and Metropolitan District Railway Companies, having definitely decided upon the details of the conversion of their lines, are determined to push the matter forward as rapidly as possible, and they have started well by placing their first large contracts in the hands of engineers who have the highest reputation for speedy and accurate work in large electric power installations.



FAC-SIMILE OF TAPE RECORD OF SIGNAL RECEIVED AT A DISTANCE OF 2,099 MILES.

Marconi's Latest Triumph.—The account of M. Marconi's latest achievement, with ocean wireless telegraphy, will be read with universal interest. *The Electrical World and Engineer* says that, beside the series of experiments conducted on board H.M.S. *Philadelphia* the Signal Hill feat pales into comparative insignificance. The inventor spent four days in overhauling and testing the transatlantic plant at Poldhu, Cornwall, arranging there the conditions to be maintained during the sending of signals and messages to him at particularised hours throughout his projected voyage on the *Philadelphia*. The signal letter to be transmitted was "S," as in the Newfoundland test, this being the easiest letter in the Morse code to transmit. It was arranged that it should be sent to him for an hour at a time at fixed intervals, with rests, for a week. A height of 150 ft. had been obtained upon the ship by the lashing of a stout spar to a mast head, a quadruple aërial being employed. It was not, however, until a point 250 miles west of the Lizard was reached that the big power-experiments commenced. It was found that the sensitiveness of the adjustments with which the best results were obtained increased but slowly. For the first thousand miles, indeed, there was no need to use any adjustment whatever of especial sensitiveness. When the connection was made after the thousand mile distance, it was discovered that the signals came as strongly and regularly as at thirty. The last message was recorded at a distance of 1,551 miles, though good "S" signals were received, with a somewhat sensitive adjustment up to 2,099 miles, made difficult to maintain by the rolling of the ship. As an illustration of the nicety of the "tuning" devices employed, it may be mentioned that the *Umbria*, which followed the experimenting ship across the ocean at a distance only of a day's steam, did not receive a single one of the signals which were flashed over her to M. Marconi's differently tuned receiver. The net results of these tests are veritably stupendous. Obtained as they were with a purely temporary installation as regards aërial capacity, it is stated that the electrical energy which has been found sufficient to send these legible signals over a distance of 2,099 miles *is not more than a mere tenth* of the supply which will be available when the tower erection at Poldhu is completed. It being now clearly shown that distance is limited only by the power available for the experiments, the curvature of the earth seems proved to be immaterial.

The "Overland Limited" New Equipment.—Entirely new cars, says the *Railroad Gazette*, are now in service on all the trains of the "Overland Limited" (Chicago and California) run, each train including a baggage, standard sleeping, buffet smoking, and library, dining, and compartment observation cars, to which the finishing touches have been put at the works of the Pullman Company. They are lighted throughout with electricity from a small direct-current plant carried in the baggage car, a 25-h.p. Westinghouse engine, direct connected to a 125-volt dynamo, being the generating unit. The current, supplied to storage batteries, is carried on the luggage car beneath the floor, from whence it is distributed to the different cars. Each sleeper is provided with about 70 incandescent lamps, and each buffet-smoking-car with 40, whilst the dining, observation, and buffet-smoking cars have each two 12-in. electric fans. Reading lamps are arranged in each section and room, electric curling-iron heaters finding a place in the ladies' toilet-room. Furthermore, barber-shops and bathrooms are comprised in the buffet, smoking, and

library car. In addition to electricity, the trains have also a complete Pintsch gas equipment. Meals *à la carte* are served in the dining-car, the ten tables in which have a seating capacity for thirty people. The sleeping-cars—containing fourteen sections and a drawing-room—have an interior finish of Cuban mahogany, with inlaid or marquetry work, carpets and upholstery of sage green, and decorations in light green and gold. Combination gas and electric fixtures adorn the imperial ceiling of the car. Quite a novel feature on these sumptuously furnished trains are the compartment cars, each of which has six compartments, a drawing-room, and large observation room. Finished in Circassian walnut, English oak, and Cuban mahogany, the compartments are fitted with folding wash-stands and every toilet accessory, the drawing-room being completed with white mahogany and green and gold decorations. Lastly, a telephone service from the train—whilst waiting in the Chicago terminal before departure — has been promised by the management, the instrument having its location in the observation car.

Marvellous Accuracy in Time Measurement.—In our distinguished contemporary, the *Journal de Physique*, MM. H. Abraham and J. Lemoine publish a very ingenious method of measuring almost incredibly small intervals of time, representing thousands of the millionth part of a second. They use the symbol m.s. to indicate the millionth part of a second, and they have succeeded in measuring time differences of not more than 0·001 m.s. It is, indeed, difficult to realise what such a time interval really means, but, as *Engineering* points out, an approximation of the idea may be obtained if we imagine that a photographic plate were attached to a projectile traversing space at a velocity of 1,000 mètres per second ; then two impressions, separated by a time interval of 0·001 m.s., would be 0·001 mm. apart on that plate. In order to solve the problem of finding the velocity of light, the distance which light travels in a certain number of seconds has been measured. This velocity (300,000 kilomètres per second) being known, it results that a distance of, *e.g.*, 30 cm., would be traversed in 0·001 m.s. This principle, which was first applied to the "Kerr phenomenon," or to the partial rotation of the plane of polarisation of a ray of plane-polarised light if reflected from the polished pole of a magnet, underlies the method employed by the two French scientists above-named. Now it happens that certain liquids, notably carbon bisulphide, become bi-refringent in an electric field. If such a liquid forms the dielectric of a condenser, and the polarising apparatus is arranged in such a manner that a ray travelling through the liquid, parallel to the condenser plates, is obscured, then the liquid will become doubly refractive, and the field therefore bright—when the condenser is charged by connecting it with a frictional electric machine, for instance. It is impossible to describe the further development of these data in the limited space at our disposal, but the detailed working out of the problem has enabled MM. H. Abraham and J. Lemoine to devise a reliable apparatus for measuring as accurately these minute time intervals as the ordinary man is able to measure the inches and half-inches contained in a foot.

On Electric Shocks. — Three papers on this subject, recently read before the Institution of Electrical Engineers, abstracted in the *Mechanical World*, should, at the present juncture, be read with general interest. The first details quite a number of experiments with shocks at 500 volts pressure, and in that connection it is shown that alternating currents are many times more painful than direct currents, the sensation, however, being of a different nature. The dangers of shocks at that pressure have been largely exaggerated and misunderstood by laymen. The writer points out that dry wood and dry boots, without large nails, offer so strong a resistance to electric current that it is quite safe to touch an overhead trolley wire whilst standing on a dry tram-car, or even when standing on the ground or on the rails — this he states from his own personal experience. However, in wet weather the case is largely altered, but even then boots must be very thoroughly saturated to permit enough current to pass to produce a severe shock. With third-rail electric railways a like immunity exists, as, with dry and sound boots, scarcely anyone can feel a shock whilst standing with one foot on the live and the other on a track rail. A shock is experienced with damp or wet boots, but neither the sensation nor the degree of wetness of the boots can be measured with any accuracy. It is further demonstrated that the conditions under which 500 volts shocks cause death are very exceptional indeed. The author of the second paper, in dealing with cases of shock received up to a 2,000 volts pressure, arrives at the conclusion that in spite of recent agitation, there is really nothing more dangerous in the alternating system than in the direct current. It is in

effect solely a question of voltage, and of the conditions being favourable. As a great number of conditions are required to be favourable, it would appear to be really difficult to get killed, even with a high voltage. Practically speaking, in fact, the chances of danger are no greater than in other occupations. The third of the papers deals with electric shock and legislation, particular reference being made to the inclusion of generating and transforming stations in the 1901 Factory Act.

Locomotive Engine Valve-Gears.—Much sensation has recently been caused by the highly glorified and, it may be said, grossly exaggerated accounts of the new valve-gear recently introduced on one of our large railway systems. We were warned to anticipate an ensuing revolution in locomotive practice. Regarded dispassionately, it may be said—as *The Engineer* points out in an able leader—that improvement can scarcely be expected on the Stephenson link, Joy's or Walschaert's gear for the heavily-loaded engine. All improvement in locomotive practice is to be looked for in two directions, either by way of increasing the hauling power of a locomotive, without a corresponding increase in fuel consumption, or by decreasing the coal weight required for the haulage of a ton per mile, the consideration being of the method in which alterations in steam distribution can assist us to that end. In order to increase the haulage power it is necessary to augment the mean effective cylinder pressure, and practically the only method of accomplishing this is by a reduction in back-pressure. Now when engines haul heavy loads speed must of necessity be slow, and at such diminished rates the back-pressure is invariably small and the diagram full. With the above quoted gears the back-pressure is really reduced to a minimum. But—the important point lies here—its magnitude does not depend upon the valve-gear at all, but on the size and arrangement of the ports and passages, and on the area of the blast-pipe. Thus no valve-gear on earth can produce such results as would be achieved with properly designed valve-gear of any of the above-named types. With those locomotives running at high speeds the case is, however, altered. Here, admittedly, it may be possible to devise a valve-gear which will give a larger continuous admission, so as to obviate wire-drawing, and which also will keep down back-pressure, but even then the reduction of back-pressure at high velocities depends on other things as well, notably the design of the cylinders with their ports and passages. In effect, so well do the present better class valve-gears perform their work, that anyone attempting a revolution of improvement will find but small margin on which to work.

The Cost of Manufacture is determined by two principal factors—(1) Wages, which chiefly depend upon the public charges and degree of civilisation that a nation has attained; and (2) Transport—*i.e.* the conditions under which raw materials reach the factory, and those under which the manufactured articles are delivered at the points of consumption. Experience would appear to show that in many cases favourable carriage rates are only obtained in the presence of competition—between one railway and another, as in Great Britain and America; and between the railways and waterways, as in Belgium and Germany. In support of this opinion, which is that of a former French Minister of Commerce and Industry, it is urged that in countries where there is competition between the railways considerable sums are spent for making waterways; and even in Belgium and Germany, where the State works a great portion of the railways and controls carriage rates, it also devotes considerable sums to making and improving canals, and this for the following reasons:—It is not merely the tariff which is interesting in the question of competition between the railway and the waterway; but also, in times of great commercial prosperity, there is no country in Europe where the rolling stock suffices for the needs of industry, and at such periods the canal serves to free the railway from obstruction; its existence saves the railway administrations from the necessity of sinking large capital in an excess of costly stock; and lastly, the canal, owing to its low rates of carriage, may foster latent traffic in the districts through which it passes. In fine, the canal, although less supple than the railway, which can even penetrate to the inside of works, maintains, notwithstanding all the progress made in railways, an undoubted superiority for carrying cheap, heavy, or cumbrous goods over long distances.

Australia to London via the Great Siberian Railway.—Nearly 10,000 miles of the new route between Adelaide, Melbourne, Sydney, Brisbane, and London, are covered by railway. The recognised line opens for serious traffic at the end of 1903, and, being made on the most modern principles as to scale and equipment, entitles it to act aggressively in securing a large share of the mail, passenger, and light express trade between Europe

and Australia. There seems no reason to doubt it will give easier, quicker, and cheaper traffic than at present by the all-water route. Its existence as a competing route, may be delayed for want of railway transport to the gateway ; or, in other words, from the Southern Australian capitals to Port Darwin ; but nevertheless, the Great Siberian railway, which is destined to play a most prominent part in the immediate history of the Far East and Australia, will prove such an important factor in the domestic traffic across the Australian continent, as to make it certain that the completion of the line to Port Darwin will, before long, be undertaken. Political considerations apart, the entry of these two "trans-continentals," fed at both termini—Port Darwin and Port Arthur—by ships of the Atlantic type, able to maintain a speed with the regularity of a railway train, would ensure a twenty days' mail and passenger service all the year round between the Australian capitals and London. The railway from west to east, from Calais to the Asian-Pacific, is a concrete fact. That its completion will have material influence on Australian interests in the future should be recognised. The quickest route between Australia and London will henceforth lie through Port Darwin and Port Arthur, the terminal points of the two great railway systems.

Armoured Bohemian Glass.—The International Congress on Fires, held at Paris in connection with the Exhibition of 1900, recommended the carrying out of certain experimental trials, under the direction of the État Major of the Sapeurs-Pompiers, for determining the resistance to fire of various materials. Among these trials were some by M. Seigle, engineer to the Neusatl Glass Company, which makes an armoured Bohemian glass, consisting of sheet glass embracing a metal trellis-work that forms one with it. Two pavilions were built, one of gypso-calcareous bricks, and the other of armoured cement, each of them however having a test panel filled in with armoured glass. In the last-named pavilion the temperature was raised to 1,150 degs. Cent. ; and the armoured glass soon cracked, but at the same time held together perfectly, and even resisted the jet of a fire hose, allowing sufficient radiant heat to pass for kindling a timber beam 8 ins. distant. In the gypso-calcareous pavilion, where the temperature was raised to 1,450 degs. Cent., the glass only cracked 24 mins. after the fire was lighted, but held together in that state until it fell in, owing to the destruction of the timber door-frame. On the fire being extinguished the glass was found to be melted in the frame, but to have still remained adherent to it. After relating these experiments, M. Boulat observes in *La Pierre Artificielle* that, although the first cost of armoured glass is naturally a little higher than that of the ordinary product, its acquirer must bear in mind that he possesses a material which will last for an almost unlimited period, effectually protecting his buildings from any fires that may extend to them and also from attempts at house-breaking, which affords protection from injury through breakage, and which will eventually to a large extent repay the greater first cost

Separation of Graphite from Pig-iron.—Having experimented with five descriptions of pig-iron, containing practically the same proportion of total carbon (about 3·3 per cent.), and in which the other elements were only present in infinitesimal proportions, except silicon—with 0·05, 0·27, 0·8, 1·2, and 2 contents—and not containing (except the last) any notable proportion of graphite, M. Georges Charpy and M. Louis Grenet arrived at the following conclusions, with respect to the separation of graphite by annealing :—1. This separation commences at a temperature so much lower as the silicon content is greater. 2. When once the separation of graphite has commenced it continues at temperatures lower than that at which the reaction began. 3. With constant temperature the separation of the graphite is effected progressively, at a speed so much slighter as the silicon content is slighter and the temperature lower. 4. The graphite content corresponding with equilibrium would appear to be but slightly dependent on the silicon content. 5. The graphite content corresponding with equilibrium increases when the temperature descends ; and at low temperatures equilibrium would appear to correspond with the absence of combined carbon.

The Explosive Qualities of Liquid and Compressed Acetylene.—Some interesting experiments for the determination of the precise liability of liquid and compressed acetylene to explode, were recently made at Berlin, the plan of operations being as follows. Various cylinders loaded with 4 kilos of liquid acetylene were placed in position, a valve being at the top, and the gas collected at the upper part of the cylinders being under a pressure of 725 lbs. per sq. in. A cartridge containing one kilo of picric acid was applied and exploded by electricity, with the result of blowing off the top of the

cylinder. The acetylene, however, was not detonated, the cylinder emptying itself on the gaseous acetylene. A second cylinder was charged with 3½ kilos of liquid, a 200-gramme cartridge being placed in the bottom. An electric current was then passed through this, the liquid acetylene exploding and destroying the cylinder. A third cylinder was fired at with a rifle without any resulting explosion, nor was a further cylinder of acetylene disturbed by the explosion of a quantity of picric acid quite near. The conclusion arrived at was that acetylene is undisturbed by sympathetic discharges, but that, a detonator being in contact therewith, the liquid will invariably explode.

A Tandem Blast-Furnace Gas-Engine.—The Bohemian Mining Company has laid down a 300-h.p. Delamare-Debouteville gas-engine at its Königshof Ironworks for working with blast-furnace gas; and this is the first engine for such working that has been made with its cylinders in line, one behind another. The diameters are 70 cm. (27 ins.), and the stroke 80 cm. (2 ft. 7 ins.). The engine makes 150 revolutions per minute, corresponding with a piston speed of 4 m. (13 ft.) per second; but the working is very regular, while there is no vibration, and no difficulty is experienced with the stuffing-boxes through which the piston-rod passes This arrangement has the advantage of great simplicity and regularity, which latter quality is due to the circumstance that the motive efforts, two for every other revolution, are distributed more uniformly than with cylinders placed opposite one another; and two effective strokes are immediately followed by two others without effort, so that a less heavy fly-wheel is sufficient, viz. one of 22 tons. The ignition of the charge is effected by the electric spark, produced by the Rhumkorff coil; and the starting is easily effected by the aspiration and compression, in the cylinders, of a small quantity of benzine, ignited at the right moment by the electric spark.

A French Record in Trains.—The progress and development of express train service in France has been, for the last few years, watched with much interest, and it may now be said, with complete truth, that the railroad system of that country—once so backward in this direction—can now rank with the best in the world. Recently, however, they have succeeded in achieving a noteworthy record, even among themselves, viz. the running of a new train, lately placed on the Paris-Calais run, which is scheduled to cover the distance of 184½ miles in three hours, this being accomplished despite the fact that there is a four minutes' stop at Amiens, and a considerable reduction in speed in passing through the town of Calais to the pier. This may be called the fastest long-distance train in the world, the average speed—61½ miles an hour—being seven miles more than that of the Empire State Express, the fastest long-distance train in America. The exact weight of the French train is not known, but it is, in all probability, less than that of the regular American Empire State train, which is 200 tons behind the engine.

Light and Power from Rapids.—The project of Engineer Dobrotvorsky for supplying St. Petersburg with light and power from the Rapids of three rivers at considerable distances from the city consists in the installation of three central stations of 28,000 to 38,000 h.p. each; in transmitting the current by high-tension lines from 110 to 170 kilometres (mean 86 miles) long; in transforming the current, and distributing it through the city, while at the same time improving the navigation of the rivers. It is estimated that, soon after the works are completed, the consumption of energy will attain 48,600 kilowatts, including the supply of 4,000 arc lamps and 300,000 incandescents, tramway traction, and various uses for motive power. The concession has been granted by the Government to a company formed especially for this object; and the cost of the enterprise is estimated at frs. 70,000,000 (£2,800,000). The public lighting is to be gratuitous; and it is hoped to furnish current to individuals at about half the cost hitherto attained in similar enterprises.

Electricity in Mine Working.—One of the most important collieries in the Charleroi district of Belgium has made arrangements for an electric generating station for transmitting mechanical energy to its three pits, separated from one another by distances of several kilometres. The station will comprise four groups of dynamos, generating polyphase current; and two dynamos of 150 kilowatts each will serve for lighting the surface works of the colliery, and also the streets of the *cité ouvrière*, or workmen's quarters. Two other groups, of 300 kilowatts each, will contribute to the lighting, and also to the distribution of power at a new pit that is being started. Pumps at the shaft bottom, 500 metres (273 fathoms) deep, will be worked electrically; and it is very probable that the electrical energy will also be applied to winding, to underground haulage, and also to the screening and washing plants. Belgians

(observes the *Moniteur Industriel* in this connection) often have very happy inspirations, and their enterprise is generally rewarded by commercial success.

Turf Charcoal Manufactured by Electricity.—A factory for treating turf electrically has been established at Stangfjorden, in Norway, the process being one patented by T. Jebsen. It is dependent upon the use of the electric current for heating purposes in retorts of special design. The turf is first dried, and is then compressed into blocks, the watery element in this way being reduced to 20 per cent. Next the blocks are enclosed in the retorts, and heated to the required temperature by internally-placed resistance coils. By these means a gas useful for heating and illumination is obtained, the tarry liquor also distilled being capable of being worked up for paraffin, methyl alcohol, and ammonium sulphate, while the turf charcoal remaining in the retorts forms an excellent substitute for either gas-coke or wood charcoal. The electrical installation at Stangfjorden includes five 128-h.p. turbines, direct coupled to five dynamos of equivalent size and capacity. Their current is employed for heating the retorts, a separate turbine supplying the necessary mechanical power.

An Ingenious Device.—A new form of speed indicator is, says the *Scientific American*, in use on one of the French railways. It is employed for locomotives where, owing perhaps to repairs, lack of attendance, bad structure, or any other reason, it is desired to keep the speed down to a certain limit. The device in question not only indicates the speed, but, when this becomes excessive, acts automatically to throw on the air-brakes. The design in question is as follows. One of the locomotive axles drives a small centrifugal pump sending water from the tender into a small cylinder, the piston of this cylinder being raised by the water against the compression of a spring, moving up and down according to the speed of the pump or locomotive. A registering apparatus, tracing a speed curve, is connected with the piston, which latter—on the speed rising above the appointed limit—acts upon a device connected with the air-brake pipes. A certain quantity of air is thus permitted to escape, throwing on the brakes.

A New Use for Peat Fibre.—Referring to our note of last month on the utilisation of peat fibre, in which it was said, "If the inventor is successful in reducing this peat yarn to a still finer thread, it will perhaps find great use in hosiery manufacture"—it is interesting to find (in the *Board of Trade Journal*) the report of a communication from a wool merchant of London. He says that the results stated as *possible* by the Düsseldorf inventor are in reality accomplished facts under the processes of manufacture by his firm. It is highly satisfactory to note that a home industry is the pioneer in the industrial application of this new fibre, the different products of which have already been placed on the market. The finer yarns spoken of, composed of a mixture of wool and the fibre, are already being made into hosiery by a leading Leicester firm. Furthermore we are informed that yarns fine enough for the manufacture of flannel equal in texture to the best French cashmeres, as well as for costume cloths, have been produced with great success.

Finely-divided Iron Ores.—In a treatise on the use of finely-divided ores obtained by concentration Prof. Wiborgh, of Stockholm, reviews the methods by which such ores can be separated mechanically or magnetically, thus permitting the utilisation of what would otherwise be wasted. The fine ore which can be smelted in the blast-furnace is limited as regards quantity by its tendency to pass through the fuel, and therefore descend without being completely reduced; but it may also be made into briquettes or turned into spongy iron. Briquettes made from fine ore cemented by quick or slaked lime, with the quantity of water necessary to make a thick paste, harden sufficiently when dried in air. What is called "ore-coke" is made by mixing the fine ore with tar or bituminous coal, 30 per cent. of the latter to 70 per cent. of iron, and highly heating the whole, which yields a hard and compact product.

The Advance of Steam Turbines.—Almost gourd-like has been the recent growth of the steam turbine in its application to large plants. Two of the most important American firms have been occupying themselves during the past few years with experiments in this direction, with the idea of improving upon existing forms. Practically speaking, all the work with large units has been achieved by the English Parsons turbine. The Westinghouse Company, which has secured all the American rights, are at present in process of building eight, ranging from 750 to 2,500 h.p. Highly satisfactory results are reported. It would appear that a 2,500-h.p. machine has been

employed for a year in an electric light and power plant at Hartford, Conn. It is said to be the largest and most economical steam engine in the world.

Tar for Laying Dust.—Ing. Rimini, of Lugo, Ravenna, has made two practical trials of coal-tar for laying dust on a road near that town, where there is considerable traffic; and, notwithstanding prolonged drought, the results exceeded his expectations. The first place treated is 13 metres (42 ft.) long by 3 metres (10 ft.) wide; and the second, 246 metres (806 ft.) by 4·7 metres (15 ft.). The surface of the road becomes very hard and compact, so that the rainfall flows off without forming mud. The expense is 0·075 lira per square metre for the first application, but diminishes for the following; and it is not necessary (observes Signor Rimini in the journal *Le Strade*) to tar the whole surface of the road, but only a band 4 metres (13 ft.) wide, so that the expense of 300 lire per kilometre (£19 6*s.* 5*d.* per mile) becomes greatly reduced.

Red Lead as an Electric Insulator.—Red lead may be regarded as an insulator, at any rate after a certain lapse of time, observes the *Farben Zeitung*. On pulling down the Bremen telegraph office in 1894, an iron joist that had been coated with red lead for eighteen years proved to be perfectly insulated; and a sensitive galvanometer, traversed by a current of 150 volts, showed no leakage. This circumstance led to experimental investigations; and it was found that a substance made of low-quality fibre surrounded by red lead is a good insulator, while also withstanding attack from the atmosphere. Red lead mixed with linseed oil has, indeed, no great insulating effect while it remains liquid; but after oxidation in the air it forms a substance that has considerable resistance to the electric current.

Mechanical Action of Gelatine on Glass, &c.—Annealed glass, when subjected to the action of gelatine, is easily attacked; and, when readily crystallisable salts that exert no chemical action upon the glass are dissolved in the gelatine, designs of crystalline appearance are produced upon its surface. It is thus that glue containing 6 per cent. of potash-alum produces designs resembling fern leaves; and sodium hyposulphite, nitre, and potassium chlorate mixed with gelatine act in nearly the same manner. These processes have been successfully applied by M. Barbey to the decoration of glass or crystal, states M. L. Cailletet; and, when sheets of cardboard, lead, or wire gauze are coated with gelatine dissolved in water, their surfaces become curved in cylindrical form as the gelatine contracts.

The Kitson Light and Fogs.—The question of placing temporary lamps in London during the heavy fogs has recently agitated at least one of the boroughs, and the Kitson Company are preparing a form of lamp similar to that known as "the Contractors," which will be placed on wheels, and which can be moved from one position to another at a moment's notice. It is quite feasible to have hundreds of these lamps distributed in this manner, and brought into operation when the fogs are densest.

Picric Acid for Motor-Cars.—This high explosive is now being used in France in conjunction with petrol for motor-cars, the spirit used being reduced by fifty per cent. by such admixture, in consequence of the large explosive force obtained. The utilisation of picric acid in this connection would, however, appear to be attended with grave danger, as it is asserted that a deposit of a by-product occurs in the combustion chamber and exhaust pipes. This by-product is an explosive compound which, if subjected to much heat, as from the sun or otherwise, causes a very bad explosion.

The Belpaire Fire-box.—The Great Eastern Railway has recently completed at the Stratford Works, its first locomotive fitted with this fire-box. The type is a six-wheel coupled engine (No. 1,189), in many respects like the 1,150 class of goods engines, which were introduced some little time ago by Mr. Holden. The boiler is 11 ft. 9 ins. in length, the internal diameter of the larger and smaller rings being 4 ft. 8 ins. and 4 ft. 7 ins., having triple-riveted lap joints. The total heating surface is 1,706·2 sq. ft., the working pressure being 180 lbs.

Project for canalising the Rhine.—South German papers announce that the kingdom of Bavaria, the Grand Duchy of Baden, and the provinces of Elsass and Lothringen have entered into a treaty for canalising the Rhine, which they propose to render navigable for large vessels from Bâle to the Swiss frontier.